Distribution of Estimated Metal Waste Amount to Cities and City Analysis, for Material Recovery System in TRNC

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ABSTRACT

Today, resource recovery takes an important place in the solid waste management of countries. On the other hand, this situation is unfortunately not valid for the TRNC. Due to the inadequate solid waste planning in TRNC, it cannot show the necessary importance to this issue. A few of the main reasons for this are the lack of recognition as an official country and the economic blockade applied. These reasons cause the situation of the country to be variable and the economy to not stabilize and to stay away from the issues that are given importance to the world. This study focuses on why it adapts to the resource recovery system in the TRNC and why and how metal material should be adhered to this system first. First of all, it estimates the amount of waste metal generated according to the cities and provides a detailed analysis on the city of Magusa. Based on this analysis, it creates a road map for the city and provides transportation network optimization by revealing the interregional relationship. Its purpose is to estimate the amount of solid waste by providing an alternative way for working on resource recovery and solid waste management system.

Keywords: solid waste, municipal waste, waste management, resource recovery, collection route optimization

ÖZ

Günümüzde kaynak geri kazanımı ülkelerin katı atık yönetiminde önemli bir yer tutmaktadır. Öte yandan bu durum, Kuzey Kıbrıs Türk Cumhuriyeti için maalesef ki geçerli değildir. Kuzey Kıbrıs'ta ki katı atık planlamasının yetersizliği yüzünden bu konuya gerekli önemi gösterememektedir. Bunun başlıca sebeblerinden bir kaçı, resmi bir ülke olarak tanınmaması ve uygulanan ekonomik ablukadır. Bu sebebler ülkenin durumunun değişken olmasına ve ekonominin stabilize olamamasına ve dünya üzerinde başlıca önem gösterilmiş konulara uzak kalmasına sebebiyet verir. Bu çalışma, Kuzey Kıbrıs Türk Cumhuriyet'inde neden kaynak geri kazanımı sistemine adapte olmasına ve bu sisteme ilk olarak neden ve nasıl metal malzemesinin adepte edilmesi gerektiği üzerine yoğunlaşır. Öncelikle şehirlere göre oluşturulan atık metal miktarını tahmin ederek, bunun üzerinde Magusa şehri ile ilgili bir detayli bir analiz sunar. Bu analizden yola çıkarak şehir için yol haritası çıkarır ve bölgeler arası ilişkiyi ortaya çıkararak, ulaşım ağı optimizasyonu sağlar. Amacı, kaynak geri kazanımı ve katı atık yönetim sistemi üzerine yapılacak çalışmalar için alternatif bir yol sunarak, katı atık miktarı tahmininde bulunmaktır.

Anahtar Kelimeler: katı atık, belediye atıkları, atık yönetimi, kaynakların geri kazanımı, toplama rutini optimizasyonu

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TRNC	Turkish Republic of Northern Cyprus

Chapter 1

INTRODUCTION

Global wastes generated are dangerous and harmful for the world. Researchers are work on this issue to use generated wastes in beneficial way. The most known ways are recycle and recovery of the waste. Year by year, researchers finding the more efficient and eco-friendly way to improve these methods. (Cifani, 2018)

Most countries around the world have integrated this system into their economies (EU, 2016). Unfortunately, TRNC is not included in this list. Even more, the waste management of the TRNC is very poor and open to developments. The main reasons for this are, complicated political situation, economic blockade and non-recognized by the world as an official country. These, cause failure to make the necessary investments & breakthroughs and inability to complete its development. There are limited resources and few study related with recycling and recovery in TRNC. For this reason, this study aims to be starting point of the system and contribute to future studies. The study focused on problem solving research. Main concept is work on many raw data and integrate the data based on decision criterion. Therefore, content of the study is try to find answers of the questions according to TRNC's dynamics. There are five main questions ‘Why material recovery system should be establish in TRNC?’ & ‘Why metal should be adapted to the material recovery system first?’ & ‘What steps should be followed to share amount of the material the cities detailed? ’

& ‘How is the city analyzed in detail, and what is needed for create city map?’ concentrate to find answers. If summarize the above explanation, mainly study focus to estimate the amount of waste for selected material, district to small region in selected city. After that by using relationship between regions in selected city, optimize the transportation network for collection route.

Material recovery is, recover the generated waste as raw material or by energy. The target of the material recovery is using waste as an input material (waste) to create valuable products as new outputs. At the end, the amount of generated waste, required landfill space is reduce and it delays the need to use raw materials in the manufacturing process. Furthermore, material recovery isn’t only related with waste management, it is part of a circular economy. (Wikipedia, Resource Recovery, 2020). Also see this, 1, 2.

Accordingly, the suitability of the metal to the material recovery system was studied. Afterwards, the amount of generated metal waste estimated and distribute to cities in TRNC. Finally, According to the amount of distributed waste, the amount of waste allocated to the regions for the city of Magusa has been estimated and a network has been created to be used in future studies by revealing the relationship between the regions.

1.1 Brief Information about TRNC

This section aims to give brief information about TRNC to understand the dynamics better. Firstly, explained the waste management of TRNC which is directly related with the study. Secondly, amount of solid waste in TRNC and then brief information about recycling and recovery in TRNC which is directly related with the study. Finally

political and economic situation the TRNC. It is not directly connected the study, however it is effect indirectly.

1.1.1 Waste Management in TRNC

TRNC has serious problems in solid waste management. These problems have a potentially significant impact on the environment and public health. For this reason, it requires urgent comprehensive recovery plans and practices in the solid waste management system. Today, solid waste management system in TRNC has the following features in general meaning.

Waste legislation for TRNC is not comprehensive; more detailed legislation is needed, covering current and future waste management systems. In addition, legislation needs to be developed in line with future EU legislation.

Monitoring and enforcement activities should be improved and more resources should be allocated to control potential environmental pollution.

Duties and responsibilities regarding solid waste management are not clear. This situation leads to some inefficiencies. For example, although there are some positive aspects of the current waste collection system, most of the 28 municipalities do their own waste collection work and the common use of vehicles and disposal areas for collection purposes remains limited. More cooperation in solid waste management due to economies of scale will have economic and environmental advantages.

Although there are some rural areas that do not receive collection services, the scope of waste collection services in terms of the population served is good.

There is very little information and data about the amount of waste generated and other aspects of waste management. There is no question of collecting and organizing the available data in a center. This complicates the planning of waste management.

In the Solid Waste Management Plan in force, it is envisaged that the most appropriate disposal system for the TRNC is a single landfill facility that will serve all municipalities. Gungor landfill facility is currently used by less than half of 28 municipalities. These municipalities account for 60-65% of the total population of the TRNC and constitute 70% of the total amount of waste collected by the municipalities.

The remaining municipalities (a few of the municipalities currently using the Gungor landfill facility) use open dumps. Some of these dumps create significant environmental risks due to the absence of disposal standards and the previously accumulated litter. In total, 50 dumps are still open and used by municipalities. These include large dumps in Famagusta and Iskele and relatively smaller dumps in other municipalities.

The capacity of the 1st stage of Gungor landfill facility has been rapidly depleted and full. The second stage started accepting waste at the end of 2018.Wastewater from septic pits is usually poured into landfills, which increases the already serious environmental, health and safety risks.

Since there is no market demand for recyclable materials, there are not many regular recycling activities today. The fact that TRNC is not recognized and under isolation greatly restricts the export of this type of waste.

Also, since most of the produced waste consists of biodegradable waste, there is the potential to obtain compost from the waste. However, the number of initiatives in this direction is still not high.

The main point of the solid waste management system is financing and cost recovery. Currently, most of the municipalities collect tariffs that cover only 30% of the current waste management costs. However, current waste removal costs are very small. Due to higher waste disposal standards, the future waste management system will be much more costly than today's system. It is essential to develop financial management and cost recovery systems to cover all operating costs and also generate income for ongoing investments. A sustainable solid waste management system will only be possible with these improvements.

The political situation of TRNC is uncertain and this affects some aspects of solid waste management, such as restrictions on waste exports. Furthermore, a significant number of tourists visit TRNC, so the amount of waste produced throughout the year varies greatly in some regions. There is an urgent need to develop and implement a strategy for improving solid waste management in TRNC, and this plan presents such a strategy.

Waste collection services are provided to the vast majority of the population 2 times a week. Collection services are routinely provided for municipal solid waste (domestic and commercial), green waste and construction and rubble waste.

Collection services are constantly interrupted due to vehicle failures and can be evaluated at the crash point or very close to the crash point. The vehicle fleets have difficulties in meeting their service demands in general, especially in the summer with tourist intensity. Fleet management and preventive maintenance is a general shortcoming, such as access to spare parts, although municipal engineers are running considerable success by operating high-aged vehicle fleets even under these conditions.

1.1.2 Recycle & Recover in TRNC

The rate is insignificantly low due to political uncertainty and inadequate infrastructure. There are few companies only have permission to collect solid waste, to prepare for recycling & recover. Because of the insufficient technology in TRNC, only opportunity is selling scraps and waste to Republic of Turkey.

1.1.3 Political and Economic Situation

TRNC, since the day it was founded (15 November 1983) unrecognized by the world as an official country. Since the ceasefire situation exists on the island, the political position has not yet stabilized and economic blockade continues to be implemented today. Therefore cannot open the economy to the world and the government cannot cover income and expenses. Financial deficit are met by the donation of Republic of Turkey. The economy of the TRNC is occurs by main three sector. These are;

- Truism sector
- High education sector
- Construction sector

Tourism and higher education are the cornerstones of TRNC's economy. The construction sector is a sector that is growing steadily.

Chapter 2

SOURCES OF INFORMATION AND LITERATURE REVIEW

2.1 Sources of Informatıon

TRNC Solid Waste Management Plan, use to understand the waste management dynamics in TRNC. “1.1.1 Waste Management in TRNC” & “1.1.2 Recycle & Recover in TRNC”. It helped to understand the weaknesses of the solid waste plan and the current situation. (E.P.D, TRNC Waste Management Plan)

TRNC Integrated Solid Waste Management Plan (2019), used figure out the total waste amount in TRNC.3.1 Solid Waste Amount in TRNC, 3.2 Estimated Population of TRNC taken from this report. Additionally, helped to understand the current situation and future plans. Basically, this study inspired from TRNC Integrated Solid Waste Management Plan (2019) to improve the solid waste management system, and how to start material recovery studies in TRNC. (E.P.D, Integrated Solid Waste Management Plan of TRNC, 2019)

Economic and Social Outlook (2017), examined to understand the social structure and economic conditions. Furthermore the report includes many detail. ” 1.1.3 Political and Economic Situation” written using this report. On the other hand the data about, industry profile, commercial enterprises and information about hospitality sector taken

from this report, “3.4 Industry Profile of TRNC” & “3.5 Commercial Enterprises” & “3.6 Hospitality Sector”. Additionally, social and economic outlook report was important to understand dynamics in TRNC. The implementation of these type of systems are expensive. Therefore, the countries which have unstable conditions should be read and understand very serious and detailed. (P.M.S.P.O., 2017)

Construction Data for the 2013 - 2016 Period (2017), used to understand construction sector in TRNC. The data about”3.7 Construction Sector” taken from this report. Construction sector in TRNC grows dramatically, therefore the sector and wastes in this sector followed. (C.T.C.C.A., 2016)

Foreign Trade Import and Export Statistics (2018), examined to understand export & import status. Additionally, data about 3.8 Imported Raw Materials” prepared by examining this report. Unfortunately, the gap between export import amounts is huge. The economic blockade is one of the serious reason. Therefore TRNC is consumer country. On the other hand, when combine the Economic and Social Outlook (2017) and Foreign Trade Import and Export Statistics (2018), helped to understand what needed for TRNC. (T.D, 2018), Also check Foreign Trade Import and Export Statistics reports 2017- 2016- 2015.

TRNC Population Census (2011), helped to do assumptions about domestic waste. (S.P.O., 2011)

TRNC Economic Indicators Report (2018) and TRNC Budget General Income-Expense Table (2018), helped to understand economic indicators in TRNC.

One of the important issue to understand the economic indicators in TRNC. Reading the economy well, gives information about how this system should be done in real life. (D.E.C.O., 2018), (F.M, 2018)

TRNC Statistical Yearbook (2017), beneficial for understand general situation in TRNC. The report is very detailed. It is recommended for those who will work about TRNC. (S.R.D, 2017)

2.2 Literature Review

The study related with Municipal solid waste management system done by G. Bueno in 25 June 2015. The target of the system was, collect the waste with a minimum environmental impact under minimum cost. The method followed was, Life cycle assessment. The model include five different waste; glass, metals, plastics and paper & cardboard. As a result, it was observed that the collection of wastes as single material causes less damage to the environment and higher efficiency. (Bueno, 2015)

It is important to adapt system to TRNC with minimum environmental impact and cost. In TRNC, due to low quality solid waste management system, hazard of the pollution is obvious. Year by year, the size of the danger is increasing. Therefore, the system will create in TRNC should meet the criteria. In other words, while the system created works at maximum efficiency, it should also provide the lowest level of environmental pollution.

The dramatic increase in population, cause increase in generated solid waste. The waste -management systems should be optimized. Because collection of the solid waste costs consume 50-80% of the low budget municipalities. Therefore the waste

management and waste collection of the municipalities should optimized continuously. Two main problem should be modelled. Waste management cost and waste management revenue. Waste management cost include collection cost, transportation cost, processing cost and constant cost depend on variables. On the other hand waste management revenue related with the recycle and recoverable materials sales. The target is increase the waste management profit by optimized the collection route between waste collection centers and transfer station. As results, studies showed that after optimized, collection path length decreased. According to this, municipality decrease the waste management cost. (Das, 2015)

In TRNC, the cost of waste collection by municipalities is high due to high maintenance costs and low labor force. Therefore, it makes it impossible to optimize the system. At the same time, no steps have been taken on recoverable & recyclable waste. Therefore collection of solid waste by municipalities is only cost.

On the other hand, R. Jacobsen (2013), made study on the cost of private and public collection of residential waste in Belgium. As method, combined qualitative and quantitative data in for case study. As result of the study, the conclusion was not clear. It was not possible to say one of them was cheapest. On the other hand both of them had advantage and disadvantage. However the results can change in future with new technologies. (Jacobsen, 2013)

This problem should be discussed for TRNC. Instead of renew all the old equipment municipalities had, would it be more efficient to collect by the private sector? This is one of the possible study subject in future.

In 1999 Ni-bin Chang, study about strategic planning of recycling drop-off stations. The aim was maximize the serviced population to drop-off stations. Minimize the walked distance between residential to drop-off station and minimize the drove distance. (CHANG, 1999)

However before creating strategic plan for TRNC, It is necessary to accustom to culture. Waste culture is important. Unfortunately, TRNC is in beginner level. Inadequate waste management applied for years is the reason. Therefore before study on strategic planning of recycling drop-off stations, the study should done for how to adapt people to this culture.

Chapter 3

COLLECTED DATA FROM SOURCES

3.1 Solid Waste Amount in TRNC

Due to lack of information and data, estimating the amount of solid waste in TRNC is really hard. The data and information in this section were created using the TRNC Integrated Solid Waste Management Plan (2019).

Based on data collected and combined, amount of solid waste in TRNC listed;

- Municipal waste
- Green waste
- Special Type Waste

3.1.1 Municipal Waste

These are solid wastes collected by municipality programmatically (twice in a week). Below table show us, the amount solid waste amount in 2020, 2025, 2030, and 2035 respectively.

Table 1: Municipal waste

	2016	2020	2025	2030	2035
TOTAL in tons	**242.664**	**286.071**	**316.130**	**340.561**	**366.883**

Type of the solid waste collected by municipality listed below;

- Kitchen waste
- Plastic packaging
- Others
- Recyclable materials except packaging
- Glass packaging
- Paper and cardboard packaging
- Green & wood
- Metal packaging

Below figure shows the ratio of each type of waste.

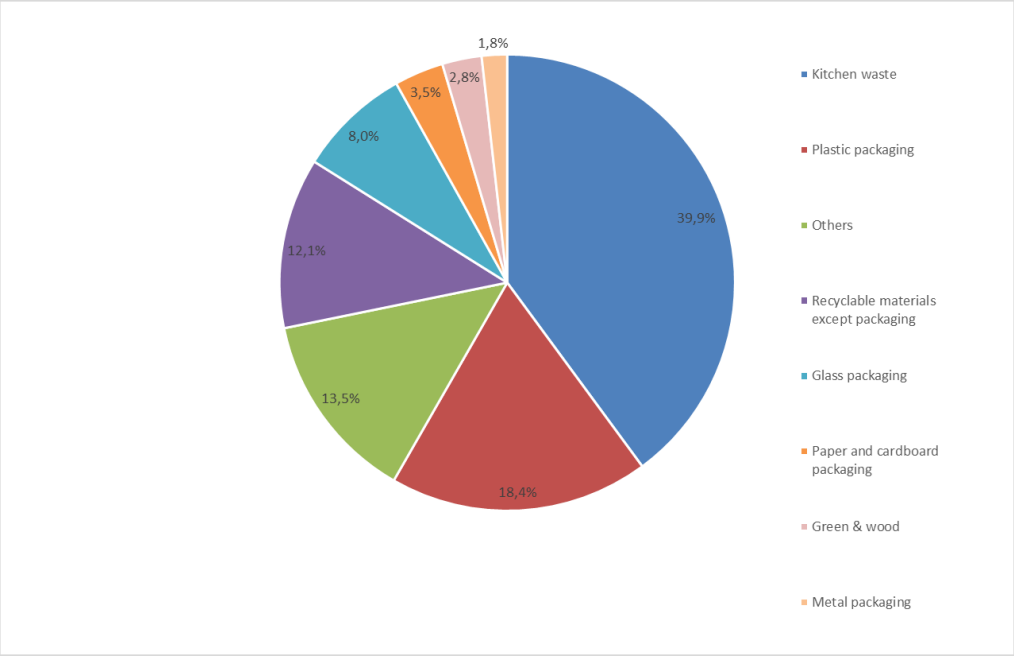

Figure 1: The ratio of each type waste

The figure shows that, almost 40% of the waste is kitchen waste. Plastic packaging waste, others, recyclable materials except packaging follows 18.4, 13.5, 12.1 percent respectively.

3.1.2 Green Waste

Green waste is generated in every season due to TRNC climate, amount estimated per year showed below table,

Table 2: Green waste amount

Type	**Amount in tons**
Green Waste	35.000

3.1.3 Special Type of Waste

Special type of solid waste include the;

- Rubble and Construction waste;

Table 3: Amount of rubble and construction waste

Region	**Rubble waste in Tons/y**	**Construction waste in Tons/y**
TOTAL	**63.000**	**47.000**

- Healthcare centers and medical waste generation;

Table 4: Amount of medical waste

	State Hospitals	**Private Clinics**
Region	**waste tons/y**	**waste tons/y**
Lefkosa	500	300
Gazimagusa	100	100
Girne	100	100
Guzelyurt	0	0
Others.	0	0
TOTAL	**700**	**500**

- Industrial waste;

There is no data available about industrial waste in TRNC, but based on industry profile of TRNC expected amount of waste is 3.600 per year. Include quarries, manufacturing (metal, textile, food, beverage, tobacco, chemicals, and plastics) and the electrical industry.

- Ship and port waste;

In 2012 and 2013, approximately 4,300 and 2,000 ships entered ports in the TRNC, respectively. However, there is no data or reliable numerical calculation for waste generation.

- Scrap vehicles;

Table 5: Amount of the vehicles

Number of registered and unregistered vehicles in the TRNC			
Year	**Registered New vehicles**	**Registered second hand vehicles**	**unRegistered vehicles**
1974-2012	65.823	85.188	16.428
2013	3.815	4.950	25
2014	3.779	4.945	20
2015	3.580	6.165	2
Total	**76.997**	**101.248**	**16.475**

- Electrical and electronic equipment;

It is estimated that approximately 7,000 8,000 tons of electrical and electronic equipment were imported to the TRNC in 2015.

- Waste oil;

Resourses of the waste oil are, mostly vehicles, industrial oil, nautical related oils.The estimation for waste oil is 1.500 ton per year.

- Scrap tires;

Approximately 350-450 tons of waste tires are produced annually in the TRNC.

- Batteries and accumulators;

Accumulators; 400-500 ton per year, batteries; 75 ton per year.

3.2 Estimated Population of TRNC

Estimated total population in 2020 is 329.494. Lefkosa as a capital city has 33,15% of the population. Magusa and Girne followed Lefkosa with 24,29 and 24,45 percent, respectively. Below table shows the information about the population.

Table 6: Estimated population in TRNC

	Population	
Region	**2020**	**Ratio**
Lefkosa	109.238	33,15%
Magusa	80.024	24,29%
Girne	80.556	24,45%
Guzelyurt	34.013	10,32%
Iskele	25.663	7,79%
TOTAL	**329.494**	

3.3 Leading Countries

Information related with Germany and Slovenia, the population, generated waste and number of facilities & plants.

Table 7: Information about Germany and Slovenia

Type/ Country	**Germany**	**Slovenia**
Recycling and Recovery Rate	66,10%	53,90%
Population	82,29 million	2,07 million
Solid waste amount	351,2 million tons (2015)	8,4 million tons (2018)

Above table shows the recycling & recovery rate, population and generated waste of Germany and Slovenia (Love Money, 2019) (Republic of Slovenia Statistic office, 2018) (Deu, 2018).

Table 8: Number of plants and facilities in Germany and Slovenia

Type/ Country	Germany	Slovenia
	Amount	
Plastic Material Recovery Facilities	244	12
Plastic Recycling Plants	157	0
Paper Material Recovery Facilities	321	13
Paper Recycling Plants	56	2
Metal Material Recovery Facilities	767	23
Metal Recycling Plants	21	2
Organic Material Recovery Facilities	77	0
Organic Recycling Plants	803	12
Glass Material Recovery Facilities	91	0
Glass Recycling Plants	8	7

Above table shows the number of recovery facilities and recycling plants of the Germany and Slovenia. (ENF, 2020)

3.4 Industry Profile of TRNC

According to TRNC Prime Ministry State Planning Organization year 2017 Economic and Social Outlook report (November 2018), there are 1854 enterprises in 11 industrial zone.

So based on below table, here is the ratio of industrial profile, 446 of the 1,854 enterprises in total are those engaged in vehicle parts and repair activities. On the other hand, Aluminum and Metal Processing Industry with 348 enterprises that occupy the largest place, in production-oriented business activities in industrial zones.

Table 9: Industrial sectors in TRNC

Types of the enterprises	**Amount**	**Ratio**
Vehicle Parts and Repair Companies	446	24,10%
Aluminum and Metal Processing Industry	348	18,80%
Food, Beverage and Tobacco Industry	275	14,86%
Forest Products and Furniture Industry	255	13,78%
Chemical and Pharmacy Products and Petroleum Petroleum, Rubber and Plastic Industry	117	6,32%
Weaving, Garments and Leather Industry	88	4,75%
Stone and Soil Based Industry(Glass, Ceramic, Cement, Lime, Marble & Ready-Mixed Concrete)	78	4,21%
IT and Electronics Industry	62	3,19%
Electrical Equipment, Machinery & Equipment Manufacturing and Assembly Industry	49	2,65%
Social Businesses	42	2,27%
Paper Products and Printing Industry	39	2,11%
Advertising	28	1,51%
Others	27	1,46%
Other Manufacturing Industry (Transportation Vehicles, Jewelery, Music and Sports Equipment, Manufacturing of Toys and Medical Products)	0	0,00%

3.5 Commercial Enterprises

Commercial enterprises generally occurs from restaurants, markets and textile in TRNC. Below table shows the total number of enterprises in TRNC.

Table 10: Number of enterprises

Region/Year	**2017**	**Ratio**
Lefkosa	7572	41,15%
Magusa	3401	18,48%
Girne	4217	22,92%
Iskele	1090	5,92%
Guzelyurt	2120	11,52%
Total	**18400**	

3.6 Hospitality Sector

Tourism is one of the leading sectors that enable the economy to spin the wheels. Below table show the amount of the hotels in cities and capacity.

Table 11: Amount of the hotels and capacity

Region	**# of hotel in 2017**	**Capacity**	**Ratio of Capacity**
Lefkosa	7	820	3,68%
Magusa	13	1765	7,93%
Girne	89	15525	69,75%
Iskele	35	4016	18,04%
Guzelyurt	5	132	0,59%
Total	**149**	**22258**	

3.7 Construction Sector

Construction industry is one of the leading sectors that enable the economy to spin the wheels. Important amount of scrap metal generated in this industry.

According to Cyprus Turkish Construction Contractors Association (2016) total project accepted is 2360. Below chart shows the confirmed construction project ratio in cities. Lefkosa leading with 34 percent and Girne followed with 24%.

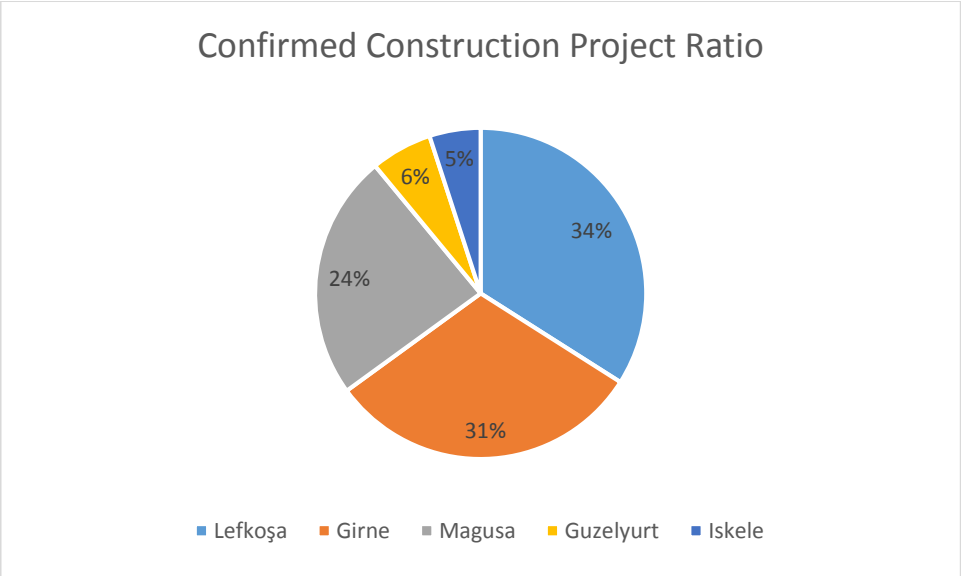

Figure 2: Construction project ratio

3.8 Imported Raw Materials

This section contain the data related imported raw material to TRNC. The examined materials were;

- Metal
- Plastic
- Paper & Cardboard
- Glass
- Rubber

Table 12: Imported metal

Metal Type	**2018** **Price in $**
IRON SHEET (GALVANIZED)	6.167.113,42
RODS OF IRON AND STEEL	1.438.336,39
ALUMINUM PLATES, SHEETS	828.177,78
ROLL PRODUCTS FROM IRON AND STEEL	712.544,69
BULLION LEAD	223.951,64
COPPER BARS	192.589,60
ALUMINUM BARS	73.897,72
ALLOY STEEL BAR	25.703,68
COPPER PLATES, SHEETS	19.331,13
GRANULES (IRON)	14.779,61
ALUMINUM ALLOYS	9.708,25
COPPER POWDERS	655,22
TOTAL	**9.706.789,13**

Table 13: Imported plastic

Plastic Type	**2018** **Price in $**
RODS FROM PLASTIC	1.356.034,04
PLASTIC RAW MATERIAL	3.301.374,74
TOTAL	**4.657.408,78**

Table 14: Imported glass

Glass Type	**2018** **Price in $**
GLASS FRACTURES AND WASTES	30.800,06
GLASS BARS	30.149,02
GLASS PIPES	3.450,23
FLOAT CAM	4.258.747,06
TOTAL	**4.323.146,37**

Table 15: Imported raw paper & cardboard

Paper & Cardboard Type	**2018**
	Price in $
PAPER RAW MATERIAL	1.304.446,40
TOTAL	**1.304.446,40**

Table 16: Imported raw rubber

Rubber Type	**2018**
	Price in $
RUBBER	97.256,76
HARDENED RUBBER	160.092,81
TOTAL	**257.349,57**

Chapter 4

METHODOLOGY OF THE STUDY

The following section describes the methodology of the study. The study focused on problem solving research. Main concept is work on many raw data and integrate the data based on decision criterion. The Microsoft Excel (2016) software used to collect and work on the data. The target of this concept is create an alternative data network and optimize the transportation network.

4.1 Research Problem

The main problem is related with insufficient solid waste management in TRNC. One of the main reasons is not to make the necessary investments due to economic uncertainties. How important resource recovery is today is clear. However, it is difficult to invest in countries with dynamically changing and unstable conditions, such as TRNC. In order to attract investments to the country, it is necessary to have precise information. Unfortunately, the amount of TRNC recoverable material is unclear. Furthermore, there is no detailed study on cities.

4.2 Research Questions

1. Why material recovery system should be establish in TRNC?

This question is related with the system can acceptable for TRNC. In the other words, examined the reasons why recovery system can applicable to the TRNC.

2. Why metal should be adapted to the system first?

The reasons of deciding metal examined.

3. What steps should be followed to share amount of the material the cities detailed?

Shared the amount of waste to cities in TRNC.

4. How is the city analyzed in detail, and what is needed for create city map?

Which steps should followed to create a material network.

4.3 Research Methods

Every question had different data set and criterion to find answer. On the other hand the questions were related with each other. The study focused on problem solving research. Main concept is work on many raw data and integrate the data based on decision criterion. Firstly**,** attribution analysis used modify and attribute the data Secondly, heuristic decision making was use to interpreted the generated data.

4.4 Research Approach

The unit used in the study is tons in terms of weight. The decimal points used for the study is 2 decimal points.

4.5 Data Collected

TRNC government official reports & books used to collect data about the study. Microsoft Excel (2016) software used to store and modify the data. Attribution Analysis used modify and attribute the data and Google Maps used for mapping to regions and points. Lingo 12 used to optimize the model created by transportation network.

4.6 Study Design and Attribution of Data

4.6.1 System for TRNC

Firstly, the system that can be suitable for TRNC should be decided between the two systems. The decision made by, examined two leading country (Material Recovery & Recycling) around the world.

The population and number of facilities & plants used as criterion to help final decision. Data related to the criteria are shown in Table 7: Information about Germany and Slovenia and Table 8: Number of plants and facilities in Germany and Slovenia. To decide what the needed system is, the economic condition, industry profile and import & export data and industry profile was used as criterion of TRNC. The target was find out the system TRNC needed.

Mentor countries have chosen to examine the system they have based on the waste produced. There were scenarios under two condition; which system applied in low / high generated waste based on material? Additionally export & imported data and industry profile examined to figure out needed system for TRNC (raw material or finished product).

The system of the countries examined by amount of the waste generated and the facilities & factories they had. It was important to understand which system select for low generated waste. In order to increase the reliability of this hypothesis, the structure of TRNC was additionally examined.

4.6.2 Decided Material

The material should be able to recovery process. The industry profile (Table 9) and imported raw material(s) (3.8 Imported Raw Materials) settled as criterion in the section. The purpose of the selected criterion, to find out the material(s) needed for TRNC. The aim of this section was understand which material is more beneficial for TRNC.

In this section, the industry profile were examined to understand which material (s) were concentrated in the TRNC. On the other words, the profile of the industry in TRNC classified base on the industry type.

The decided material should be needed in industry of TRNC to increase local sources and at the same time material should be exported. Therefore imported raw material (s) were examined to figure out which type of raw material(s) imported in terms of dollar per year.

4.6.3 Amount of Material in Cities

In this section, amount of the material in cities found out. For distribute the material decided by cities, the percentage of the suppliers should be known. The amount of generated waste in TRNC should be estimated and the material should be classified based on waste type. The following sections have been adjusted according to 2020 (5.3 Distribution Amount of the Decided Material to Cities & 5.4 Detailed Analyze for Magusa Town Center). Furthermore same method can follow to estimate the amount years by years. (The same method can be applied with minor changes for future years and other types of solid waste)

Section 3.1 Solid Waste Amount in TRNC used to estimate total amount of decided material. Furthermore, 3.2 Estimated Population of TRNC, 3.4 Industry Profile of TRNC, 3.5 Commercial Enterprises, 3.6 Hospitality Sector, 3.7 Construction Sector, sections used classify the suppliers based on decided material type. The supplier ratio of the cities should be known. Secondly, the amount of decided material should be estimated by use data collected. Finally the amount of material shared to the supplier and supplier to cities.

4.6.4 Detailed City Analyses and City Map

The city analyzed by divided into regions and points. The amount waste generated in decided city should be re-calculated. Therefore, the ratio of supplier estimates again. Because suppliers in the selected city may vary according to the area selected. The amount of waste generated varies accordingly. After the amount of waste generated for the selected area is recalculated, the area should be divided into regions and points. Regions and points examined based on properties and suppliers to find amount of material in each region.

After found out the results for each region, network should be created according to the neighborhood and distance of the regions to each other. The meaning of neighborhood was, shows the points or regions are side by side. Paths can be created between the regions using the bond between each other. Finally, the distance from center points between neighbor regions used to find average distance between two neighbor regions. The reason for choosing a neighbor criterion is because the distance between them is considered to be shorter than non-neighbors. According to this the path can created which shows al possible routes and amount of generated waste by regions and points. Later on the created possible routes optimized for collection route.

4.7 Method and Model

In this section the followed method (steps) and model created explained.

4.7.1 Algorithm-1 Decision Making

Target for TRNC;

- Improve local Resources
- Support Industry of TRNC
- Improve the number of exported Material

STEP 1: Select two leading countries (Material Recovery & Recycling) which have different properties.

Table 17: Properties of the countiries

Country 1	**Country 2**
High Population	Low Population
High Generated Waste	Low Generated Waste
High Recovery & Recycling Rate	High Recovery & Recycling Rate

STEP 2: Compare the properties of the countries.

STEP 3: Determine the number of recovery & recycling facility for each country.

STEP 4: Compare the amount of recovery & recycle facilities for each material in the leading countries.

STEP 5: Compare the amount of facilities and properties of each country.

STEP 6: Discuss the comparison.

STEP 7: Decide the applicable system for TRNC, based on target of the decision.

STEP 8: Determine the industry profile of the TRNC.

STEP 9: Determine data of imported raw materials to TRNC.

STEP 10: Compare the industry profile and imported raw materials.

STEP 11: Discuss the comparison.

STEP 12: Decide the material should adapt to the system first, based on target of the decision.

4.7.2 Algorithm-2 Distribute the Amount of Material to Cities

STEP 1: Determine the waste type and amount of selected material.

STEP 2: Determine the suppliers for each type of waste

STEP 3: Determine the supplier weight for each type of waste

STEP 4: Share the amount of waste for each type to the supplier by weight.

STEP 5: Determine the ratio of suppliers in each city

STEP 6: Distribute the amount of waste for each type, use by supplier ratio in cities.

4.7.3 Algorithm-3 Detailed City Analyzed for Material Can Collect Periodically

STEP 1: Select a city for analyze.

STEP 2: Re-update the supplier ratio for each type of waste in selected city.

STEP 3: Re-update the waste amount for each type in selected city, used by supplier ratio.

STEP 4: Separate and sort the decided city to regions and points.

STEP 5: Eliminate the overlap regions and points by combine them.

STEP 6: Examine the structure of the supplier in selected regions and points.

STEP 7: Give weights based on structure of the supplier for each type of waste.

STEP 8: Distribute the amount of waste to the regions and points by weighted supplier.

4.7.4 Model Algorithm

STEP 1: Use neighbor matrix between regions.

- 1= neighbor
- 0= otherwise

STEP 2: Find the average distance between regions and points

STEP 3: Create a network between regions and points used by neighbor matrix and average distance, include all possible routes between nodes.

STEP 4: Optimize the transportation network created

- Minimize distance

4.7.5 Transportation Model for Minimize the Distance of Collection Route

In order to solve the problem, mixed integer programming (MIP) model of the problem develop the optimize collection route by minimizing the distance between nodes used neighbor matrix.

$$x_{ij} = \left\{ \begin{array}{l} 1 \text{ if the node } i \text{ is neighbor to node } j \\ 0 \text{ otherwise} \end{array} \right\}$$

$$\min \sum_{j=N}^{i} \sum_{i=N}^{j} d_{ij}\, x_{ij} \qquad \forall\, i,j \in N \qquad (1.1)$$

subject to

$$\sum_{j=N}^{i} x_{ij} = 1 \qquad \forall\, j \in N \qquad (1.2)$$

$$\sum_{i=N}^{j} x_{ij} = 1 \qquad \forall\, i \in N \qquad (1.3)$$

$$\sum_{j=N}^{i} \sum_{i=N}^{j} x_{ij} \leq 1 \qquad \forall i,j \in N \qquad (1.4)$$

$$\sum_{j=O}^{i} x_{ij} = \sum_{i=O}^{j} x_{ij} \qquad \forall i,j \in O \qquad (1.5)$$

$$x_{ij} \in \{0,1\} \qquad \forall i,j \in N \qquad (1.6)$$

Figure 3: Mathematical model

In this model, the objective function minimization of the distance d_{ij} between the nodes x_{ij} in (1.1). Constraint (1.2) and (1.3) guaranties every nodes assigned once. On the other hand constraint (1.4) prevent the loop cycle between the nodes. Constraint (1.5) guaranties the network should start and complete at start / end point. Furthermore N= amount of nodes and O= represent the start and end point.

Chapter 5

IMPLEMENTATION AND RESULTS

5.1 Applicable System for TRNC

5.1.1 Interpretation of Data

The information related with mentor countries examined. Germany had high population and high amount generated waste than Slovenia (Table 7). On the other hand when amount of recycling plants and recovery facilities examined, except organic recycling, they focused on material recovery. (Table 8)

5.1.2 Decided System

As it turns out, countries focus more on material recovery. It has been decided that, especially the countries produced low amount of waste will be important in order to give priority to material acquisition and to develop its economy and local resources. Therefore the system decided applicable for TRNC is Material Recovery System. Furthermore, material recovery system is one of the important way to improve domestic & foreign trade. It provides strengthening of the domestic market and opening to the foreign market.

5.2 Decided Material(s)

5.2.1 Interpretation of Data

The industry profile of the TRNC is mainly concentrate to metal with 348 aluminum and metal processing factory (3.4 Industry Profile of TRNC). On the other hand metal occupied with almost 46% of imported raw material (3.8 Imported Raw Materials).

5.2.2 Decided Material(s)

Depend on two parameter (which are; Industry Profile of TRNC, Imported Raw Material(s)), it is obvious to needed every type of material as a local resource. Unfortunately, due to lack of technology for beginning, should target to only most use material which is metal in TRNC. Supporting to industry with local resource and improve the export should be the goals.

5.3 Distribution Amount of the Decided Material to Cities

5.3.1 Classification of Material

The material can classified in two groups;

- Material can be collected periodically: include domestic, commercial and industrial waste. These type of waste generally called Metal Packaging and Metal waste. These group represent the amount of waste generated on a regular basis.
- Material cannot be collected periodically; include scrap vehicles, electronic waste, and construction waste and scrap dealers. These types of waste generally called Metal Scrap. These type of waste represent the waste generated at indefinite intervals.

5.3.2 Assumptions Needed for Estimate Amount of Material

Based on section "3.1.1 Municipal Waste" recyclable materials except packaging is 12,10%. Because of the lack of data, the metal ratio inside "recyclable materials except packaging" should be assumed. The assumed ratio is 20,00% include metal.

The recoverable percent of the vehicles are 95%. On the other hand vehicles include 75,00% metal and 25,00% other type of material. The amount of unregistered vehicles (disused) are important for scrap metal. Vehicles are mostly between 1-3 tons.

Calculation continued based on average vehicle weight. Since there was no information about how many existed, it was assumed as if there were 100 in 100. For distribute the amount of scrap vehicles to cities, population ratio used.

Estimated industrial waste assumed used possible metal scrap producer enterprises ratio which was 63,59%. Therefore, at least half of the amount of waste produced assume is metal. (Appendix A: Amount and Ratio of the Potential Metal Scrap Producer Enterprises in Cities in Industry of TRNC).

Metal amount in e-waste assumed 60,00%. Below table show the total metal amount in e-waste.

Metal amount in construction waste assumed 10,00%. Below table show the total metal amount in construction waste.

5.3.3 Classification of Suppliers

There are several potential supplier, these are;

- Industrial Zone; Ratio of the industrial enterprises related with metal in cities. (Appendix A: Amount and Ratio of the Potential Metal Scrap Producer Enterprises in Cities in Industry of TRNC
- Residential Area; Population ratio in cities. (Table 6)
- Commercial Sector; Ratio of the commercial enterprises in cities.(Table 10)
- Hospitality Sector; Ratio of the hotels in cities.(Table 11)
- Construction Sector; Ratio of the confirmed construction project in cities.(Figure 2)
- Scrap dealers; NONE

Unfortunately, Because of the lack of data and information, scrap dealers were not useful source.

The percentile of suppliers based on their quantity in cities was used to distribute the amount of material to the cities.

Below table shows the suppliers ratio in cities based on material can be collected periodically.

Table 18: Ratio of the suppliers in cities (Material can be collected periodically)

Type/ Region	**Lefkosa**	**Magusa**	**Girne**	**Guzelyurt**	**Iskele**
Population Ratio	33,15%	24,29%	24,45%	10,32%	7,79%
Commercial Ratio	41,15%	18,48%	22,92%	5,92%	11,52%
Hotels Ratio	3,68%	7,93%	69,75%	18,04%	0,59%
Industry Ratio	48,47%	43,47%	4,58%	0,00%	3,47%

Below table shows the suppliers ratio in cities based on material cannot be collected periodically.

Table 19: Ratio of the suppliers in cities (Material cannot be collected periodically)

Type/ Region	**Lefkosa**	**Magusa**	**Girne**	**Guzelyurt**	**Iskele**
Population Ratio	33,15%	24,29%	24,45%	10,32%	7,79%
Commercial Ratio	41,15%	18,48%	22,92%	5,92%	11,52%
Hotel Capacity Ratio	4,70%	8,72%	59,73%	3,36%	23,49%
Industry Ratio	48,47%	43,47%	4,58%	0,00%	3,47%
Construction Ratio	34%	24%	31%	6%	5%

5.3.4 Assumption Needed for Suppliers

Before calculate the recoverable quantities, the amount of waste in domestic waste and commercial waste and hotel waste estimated together metal packaging and metal waste. Therefore weight of parameters assumed.

Below table showed assumed weights for parameters. The assumptions decided by after examined structures of the suppliers.

Table 20: Shows assumed weight for parameters

	Weight(Assumption)	
Type	**Metal Packaging**	**Metal Waste**
Population Ratio	35%	30%
Commercial Ratio	45%	30%
Hotel Ratio	20%	40%

The amount of e-waste in residential area and commercial zone, industrial zone and hotels estimated together. Therefore weight assume for parameters.

Table 21: Shows assumed weight for parameters

	Weight(Assumption)
Type	**E-Waste**
Domestic Waste	30%
Commercial Waste	25%
Hotel Waste	20%
Industry Waste	25%

5.3.5 Estimation of Recoverable Quantities

Estimation of the recoverable quantities classified in two group. As explained in above section "5.3.1 Classification of Material".

The table below shows the amount of material can be collected periodically from each producer.

Table 22: Estimated recoverable quantities in 2020- 1

Type	**Amount of Metal Packaging in ton**	**Amount of Metal Waste/Scrap in ton**
Urban Waste	1802,25	2076,67
Commercial Waste	2317,18	2076,67
Hotel Waste	1029,86	2768,89
Industrial Waste	0,00	1300,00
	5149,28	**8222,22**

The table below shows the amount of material cannot be collected periodically from each producer.

Table 23: Estimated recoverable quantities in 2020- 2

Type	**Amount of Metal Waste/Scrap in ton**
Scrap Vehicles	23476,88
Electronic Waste	600
Construction Waste	4700
Total	**28776,88**

5.3.6 Distribution of Estimated Amount to Cities

In this section the materials distributed to cities. Table 18: Ratio of the suppliers in cities (Material can be collected periodically) and Table 22: Estimated recoverable quantities in 2020- 1 used to calculate amount of metal packaging and metal

waste/scrap in cities (the amount of waste can be collected periodically). On the other hand Table 19: Ratio of the suppliers in cities (Material cannot be collected periodically) and Table 23: Estimated recoverable quantities in 2020- 2 used to calculate amount of metal scrap in cities (the amount of waste cannot be collected periodically). The amount of metals in cities estimated for 2020.

Table 24: Amount of metal packaging in cities (in tons)

Amount of Metal Packaging in Cities in tons					
Type/ Region	**Lefkosa**	**Magusa**	**Girne**	**Guzelyurt**	**Iskele**
Urban Waste	597,50	437,71	440,62	186,04	140,37
Commercial Waste	953,57	428,30	531,06	137,27	266,98
Hotel Waste	37,94	81,66	718,33	185,82	6,11
Total	**1589,01**	**947,68**	**1690,01**	**509,13**	**413,46**

Table 25: Amount of metal waste/scrap in cities (in tons)

Amount of Metal Waste/Scrap in Cities in tons					
Type/ Region	**Lefkosa**	**Magusa**	**Girne**	**Guzelyurt**	**Iskele**
Urban Waste	688,48	504,36	507,71	214,37	161,74
Commercial Waste	854,59	383,84	475,94	123,02	239,27
Hotel Waste	102,01	219,57	1931,30	499,59	16,42
Industrial Waste	630,17	565,17	59,49	0,00	45,17
Total	**2275,25**	**1672,94**	**2974,45**	**836,98**	**462,60**

Table 26: Amount of metal scrap in cities (in tons)

Amount of Waste/Scrap in Cities in tons					
Type/ Region	**Lefkosa**	**Magusa**	**Girne**	**Guzelyurt**	**Iskele**
Urban Waste	59,68	43,72	44,01	18,58	14,02
Commercial Waste	61,73	27,73	34,38	8,89	17,28
Hotel Waste	4,42	9,52	83,70	21,65	0,71
Industrial Waste	72,71	65,21	6,86	0,00	5,21
Construction Waste	1598,00	1128,00	1457,00	282,00	235,00
Scrap Vehicles	7783,35	5701,81	5739,72	2423,47	1828,52
Total	**9579,89**	**6975,98**	**7365,67**	**2754,59**	**2100,75**

5.4 Detailed Analyze for Magusa Town Center

In this section, material analyses algorithm cratered for the Magusa Town Center. The aim of this algorithm was create a material network for TRNC (because did not have precise and detailed data about material). The rest analysis and result include only material can be collected periodically (Table 24), (Table 25). First of all, amount of the material re-updated for Magusa Town Center. The following sections have been adjusted according to 2020.

5.4.1 Assumptions Needed for Detailed Analyses in Magusa Town Center

There is no certain information about the number of commercial enterprises in Magusa. Therefore the number should be assume. However, it is known most of them concentrate in Magusa due to population ratio. Assumption is 75% is concantrate in Magusa Town Center.

Generated waste by decided hotels assumed based on capacity of the hotels 60%.

5.4.2 Re-Update to Amount of Waste Produced in Suppliers

The ratio of the supplier in Magusa Town center should be update.

Population ratio of the Magusa District concentrate in Magusa Central Sub-District with 72,15 %. On the other hand Magusa Central Sub-District concentrate Magusa Municipality with 76,69%. On the other hand the amount of waste generated by commercial enterprises assumed 75%. Amount of waste generated by industrial zone decided to use three industrial regions in Magusa District. The reason was, proximity to each other. The percent of the industrial zones were 45,05, 11,32 and 34,89 respectively. Famous 6 hotel selected in Magusa District. Selected hotels separated in

two groups. These are the hotels in Magusa Town center and outside the town. Below table shows re-updated amount of urban, commercial, industrial and hotel waste.

Table 27: Re-Updated waste amount for Magusa district

		Metal Packaging	**Metal Waste/Scrap**
Type	**Region**	**Amount in tons**	**Amount in tons**
Urban Waste	Magusa	242,20	279,08
Commercial Waste	Magusa	321,23	287,88
Industrial Waste	Magusa Organized Industrial Zone	-	254,55
Industrial Waste	Magusa Small Industry Zone	-	63,98
Industrial Waste	Guvercinlik (I-II) Industrial Zone	-	197,19
Hotel Waste	Magusa	49,00	131,74

5.6 Mapping the Selected City

In this section regions and points decided to create a map in Magusa town.

5.6.1 Decided Regions and Points

Decided regions for Magusa Town were;

- Maras
- Baykal
- Palmbeach
- Dumlupınar
- Canakkale
- Sakarya
- Karakol
- Tuzla
- Magusa Organized Industrial Zone
- Magusa Small Industry Zone
- Guvercinlik (I-II) Industrial Zone

Decided points (symbol of the points are STAR), Hotels inside of the city;

- Arkın Palm Beach Hotel (purple)
- Port View Hotel (green)
- Premium Inn Hotel (yellow)
- Ingate Hotel (Blue)

Decided points, Hotel outside of the city;

- Salamis Hotel (orange)
- Venus Hotel (brown)

Since the determined regions and points overlap, they should be considered as one. These are;

- Magusa Small Industry Zone (purple) inside the Baykal (2)
- Premium Inn Hotel (yellow) in Karakol (7)
- Port View Hotel (green) in Dumlupınar (4)
- Ingate Hotel (blue) in Dumlupınar (4)
- Palmbeach Hotel (purple) in Palmbeach (3)

Re-Organized list;

1. Maras
2. Baykal
3. Palmbeach
4. Dumlupınar
5. Canakkale
6. Sakarya
7. Karakol
8. Tuzla
9. Magusa Organized Industrial Zone
10. Guvercinlik (I-II) Industrial Zone
11. Salamis Hotel
12. Venus Hotel

So below figure shows the Regions and point based on above list

Figure 4: Regions and points

5.6.2 Assumptions Needed to Estimate Amount in each Region

The amount of waste should allocate to regions. Due to lack of the data, the weights assume by examined the information and structure of the regions (except industrial zones). This assumption may be changed in the future by collecting data.

5.6.3 Estimated Amount based on Regions

Table 28: Amount of urban waste in regions (in tons)

Region	Assumption	**Urban Waste**	
	Weight	**Metal Packaging**	**Metal Scrap**
Maras	20%	48,44	55,82
Baykal	13%	31,49	36,28
Palmbeach	0,5%	1,21	1,40
Dumlupınar	13%	31,49	36,28
Canakkale	13%	31,49	36,28
Sakarya	13%	31,49	36,28
Karakol	13%	31,49	36,28
Tuzla	15%	35,12	40,47
Total	**100%**	242,20	279,08

Table 29: Amount of commercial waste in regions (in tons)

Region	Assumption	**Commercial Waste**	
	Weight	**Metal Packaging**	**Metal Scrap**
Maras	10%	32,12	28,79
Baykal	7%	22,49	20,15
Palmbeach	2%	6,42	5,76
Dumlupınar	13%	41,76	37,42
Canakkale	15%	48,18	43,18
Sakarya	27%	86,73	77,73
Karakol	22%	70,67	63,33
Tuzla	4%	12,85	11,52
Total	**100%**	321,23	287,88

Table 30: Amount of hotel waste in regions (in tons)

Name	Assumption	Hotel waste	
	Weight	**Metal Packaging**	**Metal Scrap**
Salamis Hotel	35%	17,15	46,11
Venus Hotel	10%	4,9	13,17
Arkın Palm Beach Hotel	25%	12,25	32,94
Port View Hotel	20%	9,8	26,35
Premium Inn Hotel	5%	2,45	6,59
Ingate Hotel	5%	2,45	6,59
Total	**100%**	49,00	131,74

Table 31: Amount of industrial waste in regions (in tons)

Region	Industrial Waste in ton
	Metal Scrap
Magusa Organized Industrial Zone	254,55
Magusa Small Industry Zone	63,98
Guvercinlik (I-II) Industrial Zone	197,19
Total	515,72

5.6.4 Final Review of the Amount in each Region

Below table shows the final result after combine overlapping points**.**

Table 32: Final review of the waste amount in each region in 2020 (in tons)

Regions & Points	Metal Packaging	Metal Scrap
Maras	80,56	84,60
Baykal	53,97	120,41
Palmbeach	19,89	40,09
Dumlupınar	85,50	106,64
Canakkale	79,67	79,46
Sakarya	118,22	114,01
Karakol	104,61	106,20
Tuzla	47,97	51,98
Industrial Zone (1)	-	254,55
Industrial Zone (3)	-	197,19
Salamis Hotel	17,15	46,11
Venus Hotel	4,90	13,17
Total	**612,43**	**1214,42**

5.6.5 Classify the Relationship between Agreed Regions

Neighbor relationship between regions and points, shown in binary matrix. In binary matrix; 1 represent if regions are neighbor and 0 represent otherwise (Korhan, 2020).

The size of the matrix is 12x12. The matrix shows all regions and points after eliminated overlapping regions and points.

Regions & Points	Maras	Baykal	Palmbeach	Dumlupınar	Canakkale	Sakarya	Karakol	Tuzla	Industrial Zone (1)	Industrial Zone (3)	Salamis Hotel	Venus Hotel
Maras	-	1	1	1	1	0	0	0	0	0	0	0
Baykal	1	-	0	1	1	1	0	0	0	0	0	0
Palmbeach	1	0	-	1	0	0	0	0	0	0	0	0
Dumlupınar	1	1	1	-	0	1	1	0	0	0	0	0
Canakkale	1	1	0	0	-	1	0	0	1	0	0	0
Sakarya	0	1	0	1	1	-	1	1	1	0	0	0
Karakol	0	0	0	1	0	1	-	1	0	0	0	0
Tuzla	0	0	0	0	0	1	1	-	1	0	0	0
Industrial Zone (1)	0	0	0	0	1	1	0	1	-	1	0	0
Industrial Zone (3)	0	0	0	0	0	0	0	0	1	-	0	0
Salamis Hotel	0	0	0	0	0	0	0	0	0	0	-	1
Venus Hotel	0	0	0	0	0	0	0	0	0	0	1	-

Figure 5: Neighbor matrix

Secondly the distance between neighbor regions must be examined. The distance shown in square matrix. Below figure shows the distance (in km) between regions from the center point (Korhan, 2020).

The size of the matrix is 12x12. Below figure shows the average distance between neighboring regions. (Appendix B: Distance Network between Regions and Points)

Distance between center point (in km)	Maras	Baykal	Palmbeach	Dumlupınar	Canakkale	Sakarya	Karakol	Tuzla	Industrial Zone (1)	Industrial Zone (3)	Salamis Hotel	Venus Hotel
Maras	-	2,43	2,38	2,91	3,38	-	-	-	-	-	-	-
Baykal	2,43	-	-	0,95	1,24	2,67	-	-	-	-	-	-
Palmbeach	2,38	-	-	0,97	-	-	-	-	-	-	-	-
Dumlupınar	2,91	0,95	0,97	-	-	2,78	2,94	-	-	-	-	-
Canakkale	3,38	1,24	-	-	-	1,72	-	-	-	-	-	-
Sakarya	-	2,67	-	2,78	1,72	-	0,95	3,09	2,02	-	-	-
Karakol	-		-	2,94	-	0,95	-	3,06	-	-	-	-
Tuzla	-		-	-	-	3,09	3,06	-	1,39	-	-	4,05
Industrial Zone (1)	-		-	-	3,28	2,02	-	1,39	-	1,88	1,47	-
Industrial Zone (3)	-		-	-	-	-	-	-	1,88	-	-	-
Salamis Hotel	-		-	-	-	-	-	-	-	-	-	1,47
Venus Hotel	-		-	-	-	-	-	4,05	-	-	-	-

Figure 6: Distance between neighbors

5.6.6 Path(S) Between Regions and Points

Finally using above figures (Figure 3 & Figure 4) the network created include all possible path, for label nodes section 5.6.1 Decided Regions and Points were use (Guden, 2020).

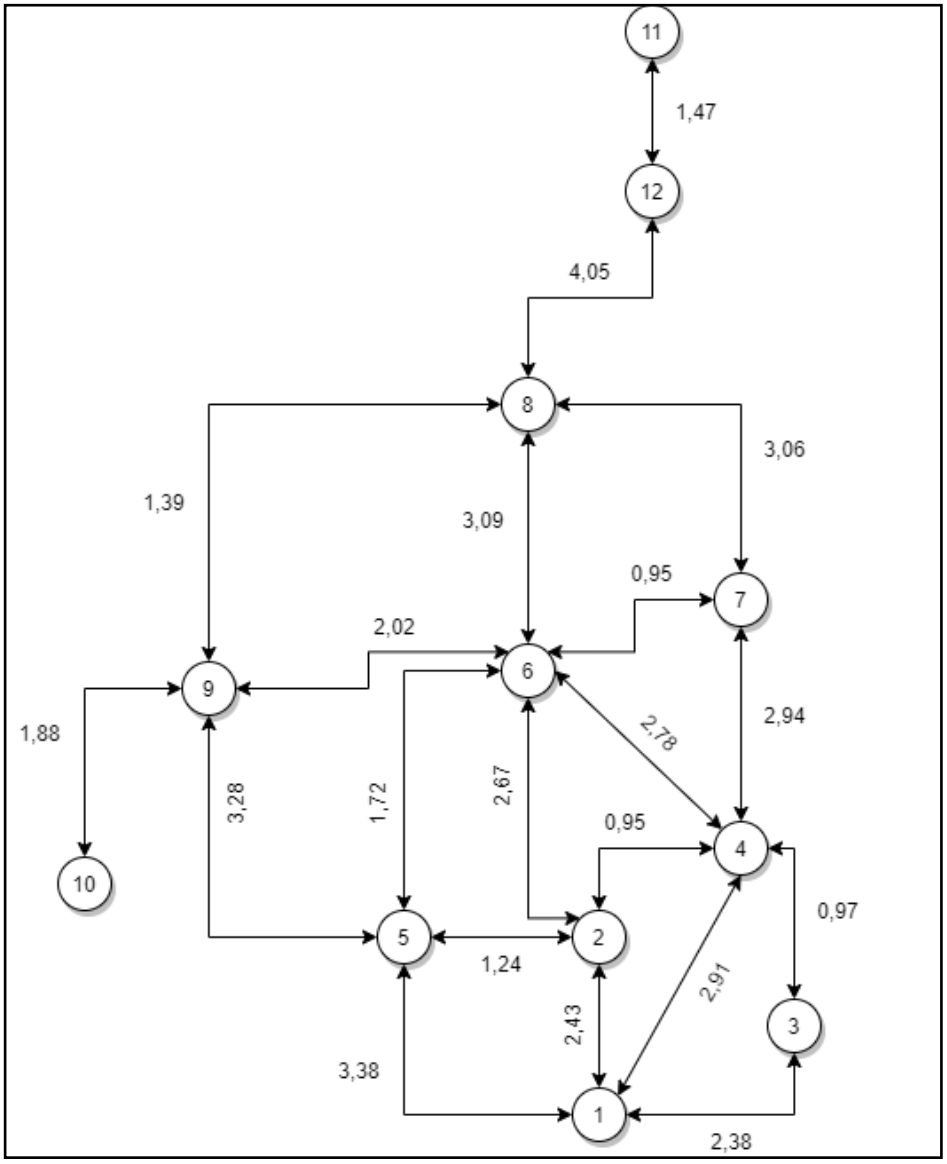

Figure 7: All possible paths between regions

Above figure shows the path created between the nodes based on the neighborhood. The number between the nodes represent average distance between the nodes.

5.6.7 Optimization of the Transportation Network

There are 12 nodes and two end point (10 & 11) in Figure 7, therefore the network simplified 1-9 nodes to reach an optimum solution. On the other hand, the solution of the model used to cover the 10-12-11 nodes, using neighbor relation. For an example, in the solution when reach the node 8, node 12-11 should cover, later on continue to solution path given by lingo.

Another important situation is, the model designed for start & end point. These start & end point can be warehouse for store the waste. In the study, the location of warehouse(s) didn't mention. Therefore node 0 added to the model as start & end point in two scenario. First scenario include, warehouse hasn't any effect on objective function and it is neighbor with 9 other nodes (Appendix C: Model for Scenario-1). Second scenario include, warehouse effect the objective function, because the distance between warehouse and 9 other nodes assumed as any number positive random number in objective function (Appendix D: Model for Scenario-2).When solving the model for both scenario, the solution was looping. Sub-tour elimination constraints have been added to prevent this. These constraints are; also see (Appendix C: Model for Scenario-1) & (Appendix D: Model for Scenario-2).

$$x_{67} + x_{76} + x_{68} + x_{86} + x_{69} + x_{96} + x_{78} + x_{87} + x_{79} + x_{97} + x_{89} + x_{98} \leq 3$$

$$x_{12} + x_{21} + x_{13} + x_{31} + x_{14} + x_{41} + x_{23} + x_{32} + x_{24} + x_{42} + x_{34} + x_{43} \leq 3$$

Result for Scenario-1 (Appendix E: Result for Scenario-1) ;

```
Global optimal solution found.
Objective value:                              12.66000
Objective bound:                              12.66000
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                            43

Model Class:                                      MILP

Total variables:                     56
Nonlinear variables:                  0
Integer variables:                   52

Total constraints:                   50
Nonlinear constraints:                0

Total nonzeros:                     230
Nonlinear nonzeros:                   0
```

Figure 8: Result for scenario-1

Above figure shows the optimum solution for scenario-1. The objective value (minimized distance) 12.66 km.

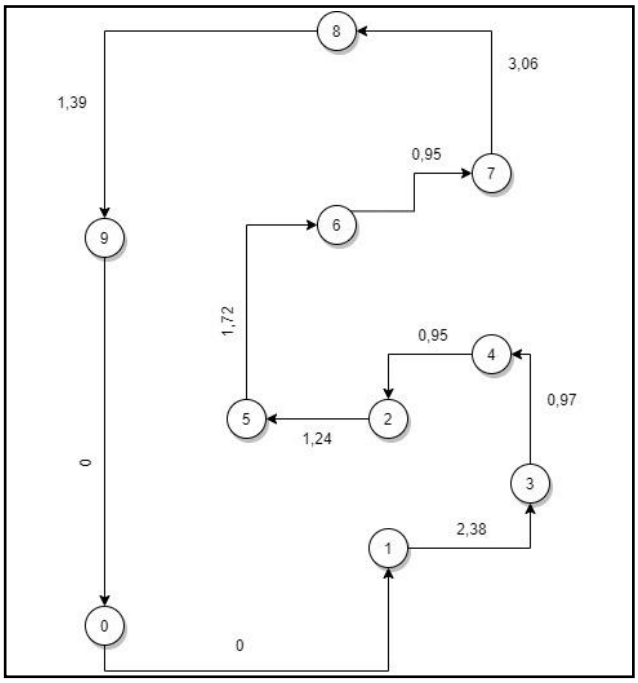

Figure 9: Solution of scenario-1 on network

Above figure shows the optimum Path should follow= 0-1-3-4-2-5-6-7-8-9-0. On the other hand node 10-11-12 should add the solution manually. Therefore; Solution should be 0-1-3-4-2-5-6-7-8-12-11-8-9-10-9-0. The illustration below shows the solution node 10, 11, 12 added manually and distance count twice (round-trip) between the linked nodes. Therefore objective value is; 12.66+ ((2*1.88) + (2*4.05) + (2*1.47)) = 27.46km.

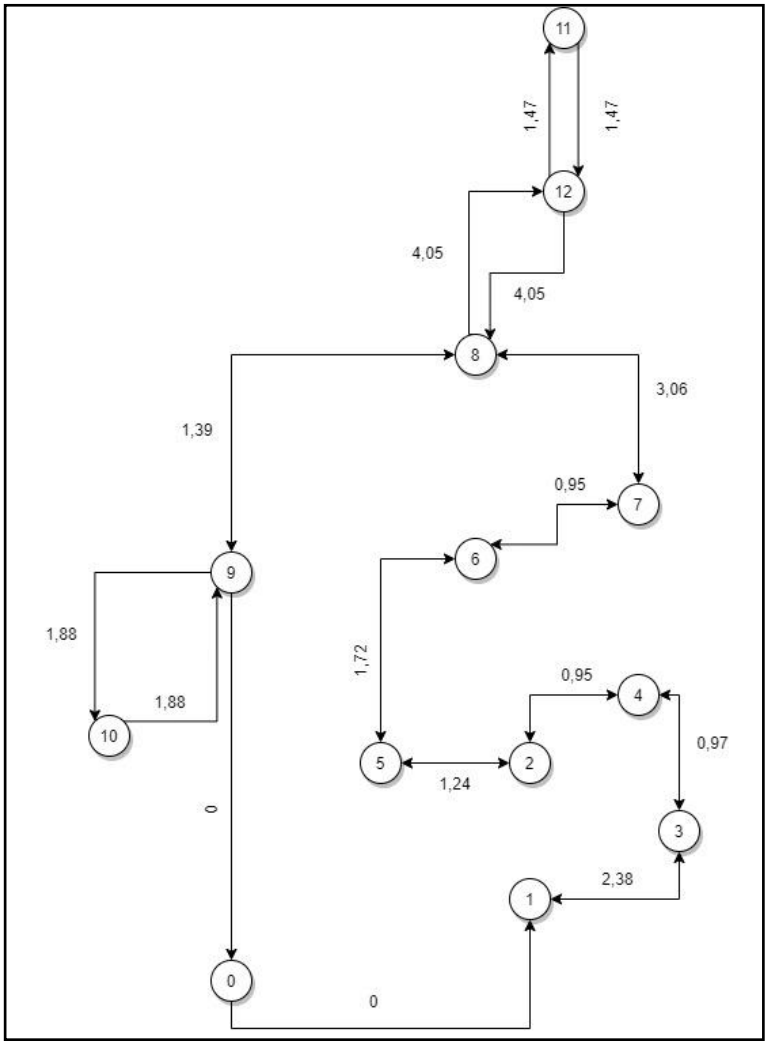

Figure 10: Solution of scenario-1 with added nodes

Result for Scenario-2 (Appendix F: Result for Scenario-2)

```
Global optimal solution found.
Objective value:                              18.56000
Objective bound:                              18.56000
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                            79

Model Class:                                      MILP

Total variables:                     56
Nonlinear variables:                  0
Integer variables:                   52

Total constraints:                   79
Nonlinear constraints:                0

Total nonzeros:                     340
Nonlinear nonzeros:                   0
```

Figure 11: Result for scenario-2

Above figure shows the optimum solution for scenario-2. The objective value (minimized distance) 18.56 km.

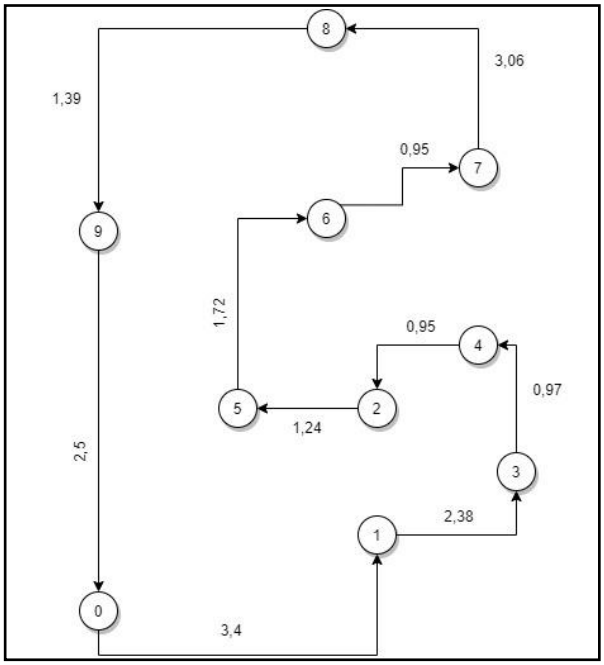

Figure 12: Solution path for scenario-2

Above figure shows the optimum Path should follow= 0-1-3-4-2-5-6-7-8-9-0. On the other hand, the optimum path is same as scenario 1, therefore node 10-11-12 should add the solution manually. Therefore; Solution should be 0-1-3-4-2-5-6-7-8-12-11-8-9-10-9-0. The illustration below shows the solution node 10, 11, 12 added manually and distance count twice (round-trip) between the linked nodes. Therefore objective value is; 18.56 + ((2*1.88) + (2*4.05) + (2*1.47)) = 33.36 km.

Because the solution of scenario 1 and scenario 2 is same, same path in Figure 10 should follow. Only diffirence distance between initial and end node instead of zero, random positive number. Also see this Appendix F: Result for Scenario-2.

Chapter 6

CONCLUSION AND FUTURE STUDIES

The study, focus to the answer unclear or unknown questions on a waste management system that needs improvement for TRNC. The dynamics and source information related with TRNC, used to estimate the answer of unknown questions. After all, It was determined that the system suitable for TRNC is material recovery. The metal was decided to adapt material recovery system as first material. The reason for this decision is that the raw material recovery would be more suitable for TRNC and the processing industry was concentrated on metal. Thus, local resources could be increased. Secondly the study focus to estimate the recoverable metal material by cities. Therefore the supplier were classify. Assumptions were made in the parts where data and information were lacking. Finally, detailed analyses made for Magusa town center to distribute the amount of generated waste selected regions and points in Magusa town center. According to this, the path can created which shows al possible routes and amount of generated waste by regions and points. The path between nodes minimized by cover every node. Transportation network optimized by created model related with relationship of regions and solved in Lingo. This study can applied for any selected material and city in TRNC.

As the next step in future, focus to study about material recovery facility in TRNC. This field of study will be a continuation of the previous study. Because of the economic blockade and limitations, the feasibility analyses related with material

recovery facility recommended for future studies. Furthermore, as a side study, optimizing the waste collection route, minimizing the environmental hazard of recovery facility can work on it. Finally, a study on TRNC can be done to encourage people to recycle and recover. The studies mentioned above can be described as complementary to each other.

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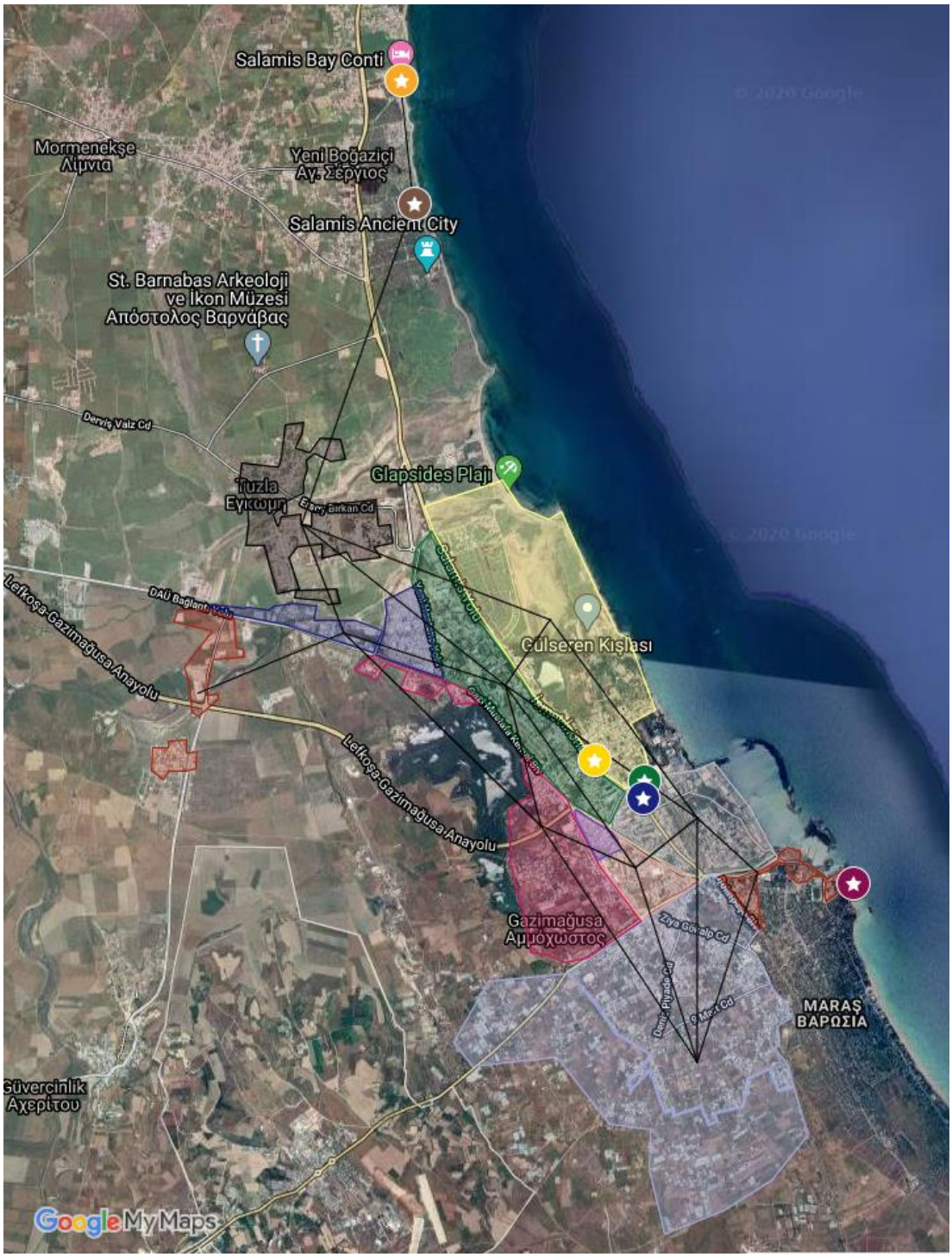
APPENDICES

Appendix A: Amount and Ratio of the Potential Metal Scrap Producer Enterprises in Cities in Industry of TRNC

Type	Lefkoşa	Magusa	Girne	Güzelyurt	İskele
Vehicle Parts and Repair Companies	192	219	14	0	21
Aluminum and Metal Processing Industry	180	141	14	0	13
Food, Beverage and Tobacco Industry	149	104	19	0	3
IT and Electronics Industry	30	25	4	0	3
Electrical Equipment, Machinery & Equipment Manufacturing and Assembly Industry	21	24	3	0	1
Total	572	513	54	0	41
Ratio	48,47%	43,47%	4,58%	0,00%	3,47%

Appendix B: Distance Network between Regions and Points



Appendix C: Model for Scenario-1

```
min=2.43*x12+2.38*x13+2.91*x14+3.38*x15+2.
43*x21+0.95*x24+1.24*x25+2.67*x26+2.38*x31
+0.97*x34+2.91*x41+0.95*x42+0.97*x43+2.78*
x46+2.94*x47+3.38*x51+1.24*x52+1.72*x56+3.
28*x59+2.67*x62+2.78*x64+1.72*x65+0.95*x67
+3.09*x68+2.02*x69+2.94*x74+0.95*x76+3.06*
x78+3.09*x86+3.06*x87+1.39*x89+3.28*x95+2.
02*x96+1.39*x98+0*x01+0*x02+0*x03+0*x04+0*
x05+0*x06+0*x07+0*x08+0*x09+0*x10+0*x20+0*
x30+0*x40+0*x50+0*x60+0*x70+0*x80+0*x90;

x01+x02+x03+x04+x05+x06+x07+x08+x09=1;
x10+x12+x13+x14+x15=1;
x20+X21+X24+X25+X26=1;
x30+x31+x34=1;
x40+x41+x42+x43+x46+x47=1;
x50+x51+x52+x56+x59=1;
x60+x62+x64+x65+x67+x68+x69=1;
x70+x74+x76+x78=1;
x80+x86+x87+x89=1;
x90+x95+x96+x98=1;

x10+x20+x30+x40+x50+x60+x70+x08+x90=1;
x01+x21+x31+x41+x51=1;
x02+x12+x42+x52+x62=1;
x03+x13+x43=1;
x04+x14+x24+x34+x64+x74=1;
x05+x15+x25+x65+x95=1;
x06+x26+x46+x56+x76+x86+x96=1;
x07+x47+x67+x87=1;
x08+x68+x78+x98=1;
x09+x59+x69+x89=1;

x67+x76+x68+x86+x69+x96+x78+x87+x79+x97+x8
9+x98<=3;
x12+x21+x13+x31+x14+x41+x23+x32+x24+x42+x3
4+x43<=3;

x01+x02+x03+x04+x05+x06+x07+x08+x09=x10+x2
0+x30+x40+x50+x60+x70+x08+x90;

x10+x01<=1;
x20+x02<=1;
x30+x03<=1;
x40+x04<=1;
x50+x05<=1;
x60+x06<=1;
x70+x07<=1;
x80+x08<=1;
x90+x09<=1;
x12+x21<=1;
x13+x31<=1;
x14+x41<=1;
x15+x51<=1;
x24+x42<=1;
x25+x52<=1;
x26+x62<=1;
x34+x43<=1;
x46+x64<=1;
x47+x74<=1;
x56+x65<=1;
x59+x95<=1;
x67+x76<=1;
x68+x86<=1;
x69+x96<=1;
x78+x87<=1;
x89+x98<=1;

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```

Appendix D: Model for Scenario-2

```
min=2.43*x12+2.38*x13+2.91*x14+3.38*x15+2.
43*x21+0.95*x24+1.24*x25+2.67*x26+2.38*x31
+0.97*x34+2.91*x41+0.95*x42+0.97*x43+2.78*
x46+2.94*x47+3.38*x51+1.24*x52+1.72*x56+3.
28*x59+2.67*x62+2.78*x64+1.72*x65+0.95*x67
+3.09*x68+2.02*x69+2.94*x74+0.95*x76+3.06*
x78+3.09*x86+3.06*x87+1.39*x89+3.28*x95+2.
02*x96+1.39*x98+3.4*x01+3.9*x02+3.5*x03+3.
7*x04+2*x05+3.1*x06+2.1*x07+2.7*x08+2.5*x0
9+3.4*x10+3.9*x20+3.5*x30+3.7*x40+2*x50+3.
1*x60+2.1*x70+2.7*x80+2.5*x90;

x01+x02+x03+x04+x05+x06+x07+x08+x09=1;
x10+x12+x13+x14+x15=1;
x20+X21+X24+X25+X26=1;
x30+x31+x34=1;
x40+x41+x42+x43+x46+x47=1;
x50+x51+x52+x56+x59=1;
x60+x62+x64+x65+x67+x68+x69=1;
x70+x74+x76+x78=1;
x80+x86+x87+x89=1;
x90+x95+x96+x98=1;

x10+x20+x30+x40+x50+x60+x70+x08+x90=1;
x01+x21+x31+x41+x51=1;
x02+x12+x42+x52+x62=1;
x03+x13+x43=1;
x04+x14+x24+x34+x64+x74=1;
x05+x15+x25+x65+x95=1;
x06+x26+x46+x56+x76+x86+x96=1;
x07+x47+x67+x87=1;
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x09+x59+x69+x89=1;

x67+x76+x68+x86+x69+x96+x78+x87+x79+x97+x8
9+x98<=3;
x12+x21+x13+x31+x14+x41+x23+x32+x24+x42+x3
4+x43<=3;

x01+x02+x03+x04+x05+x06+x07+x08+x09=x10+x2
0+x30+x40+x50+x60+x70+x08+x90;




x10+x01<=1;
x20+x02<=1;
x30+x03<=1;
x40+x04<=1;
x50+x05<=1;
x60+x06<=1;
x70+x07<=1;
x80+x08<=1;
x90+x09<=1;
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x13+x31<=1;
x14+x41<=1;
x15+x51<=1;
x24+x42<=1;
x25+x52<=1;
x26+x62<=1;
x34+x43<=1;
x46+x64<=1;
x47+x74<=1;
x56+x65<=1;
x59+x95<=1;
x67+x76<=1;
x68+x86<=1;
x69+x96<=1;
x78+x87<=1;
x89+x98<=1;


@bin(x12);
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```

Appendix E: Result for Scenario-1

Variable	Value	Reduced Cost
X12	0.000000	2.430000
X13	1.000000	2.380000
X14	0.000000	2.910000
X15	0.000000	3.380000
X21	0.000000	2.430000
X24	0.000000	0.9500000
X25	1.000000	1.240000
X26	0.000000	2.670000
X31	0.000000	2.380000
X34	1.000000	0.9700000
X41	0.000000	2.910000
X42	1.000000	0.9500000
X43	0.000000	0.9700000
X46	0.000000	2.780000
X47	0.000000	2.940000
X51	0.000000	3.380000
X52	0.000000	1.240000
X56	1.000000	1.720000
X59	0.000000	3.280000
X62	0.000000	2.670000
X64	0.000000	2.780000
X65	0.000000	1.720000
X67	1.000000	0.9500000
X68	0.000000	3.090000
X69	0.000000	2.020000
X74	0.000000	2.940000
X76	0.000000	0.9500000
X78	1.000000	3.060000
X86	0.000000	3.090000
X87	0.000000	3.060000
X89	1.000000	1.390000
X95	0.000000	3.280000
X96	0.000000	2.020000
X98	0.000000	1.390000
X01	1.000000	0.000000
X02	0.000000	0.000000
X03	0.000000	0.000000
X04	0.000000	0.000000
X05	0.000000	0.000000
X06	0.000000	0.000000
X07	0.000000	0.000000
X08	0.000000	0.000000
X09	0.000000	0.000000
X10	0.000000	0.000000
X20	0.000000	0.000000
X30	0.000000	0.000000
X40	0.000000	0.000000
X50	0.000000	0.000000
X60	0.000000	0.000000
X70	0.000000	0.000000
X80	0.000000	0.000000
X90	1.000000	0.000000
X79	0.000000	0.000000
X97	0.000000	0.000000
X23	0.000000	0.000000
X32	0.000000	0.000000

Appendix F: Result for Scenario-2

Variable	Value	Reduced Cost
X12	0.000000	2.430000
X13	1.000000	2.380000
X14	0.000000	2.910000
X15	0.000000	3.380000
X21	0.000000	2.430000
X24	0.000000	0.9500000
X25	1.000000	1.240000
X26	0.000000	2.670000
X31	0.000000	2.380000
X34	1.000000	0.9700000
X41	0.000000	2.910000
X42	1.000000	0.9500000
X43	0.000000	0.9700000
X46	0.000000	2.780000
X47	0.000000	2.940000
X51	0.000000	3.380000
X52	0.000000	1.240000
X56	1.000000	1.720000
X59	0.000000	3.280000
X62	0.000000	2.670000
X64	0.000000	2.780000
X65	0.000000	1.720000
X67	1.000000	0.9500000
X68	0.000000	3.090000
X69	0.000000	2.020000
X74	0.000000	2.940000
X76	0.000000	0.9500000
X78	1.000000	3.060000
X86	0.000000	3.090000
X87	0.000000	3.060000
X89	1.000000	1.390000
X95	0.000000	3.280000
X96	0.000000	2.020000
X98	0.000000	1.390000
X01	1.000000	3.400000
X02	0.000000	3.900000
X03	0.000000	3.500000
X04	0.000000	3.700000
X05	0.000000	2.000000
X06	0.000000	3.100000
X07	0.000000	2.100000
X08	0.000000	2.700000
X09	0.000000	2.500000
X10	0.000000	3.400000
X20	0.000000	3.900000
X30	0.000000	3.500000
X40	0.000000	3.700000
X50	0.000000	2.000000
X60	0.000000	3.100000
X70	0.000000	2.100000
X80	0.000000	2.700000
X90	1.000000	2.500000
X79	0.000000	0.000000
X97	0.000000	0.000000
X23	0.000000	0.000000
X32	0.000000	0.000000