DEFINING NEW POLITICAL TOOLS FOR MUNICIPAL SOLID WASTE MANAGEMENT OF ANKARA METROPOLITAN MUNICIPALITIY AFTER REVISION OF METROPOLITAN MUNICIPALITY LAW IN 2014

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ABSTRACT

DEFINING NEW POLITICAL TOOLS FOR MUNICIPAL SOLID WASTE MANAGEMENT OF ANKARA METROPOLITAN MUNICIPALITIY AFTER REVISION OF METROPOLITAN MUNICIPALITY LAW IN 2014

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By the date of March 30th of 2014, law no 6360 has come into force that extends the responsibilities of Metropolitan Municipalities to the provincial administrative boundaries. This extension creates new responsibilities for Metropolitan Municipalities regarding environmental services including solid waste management. The aim of this study is (a) to develop new political tools that Metropolitan Municipalities will need to fulfill their obligations under this new law in the area of solid waste management, and (b) to consider possible alternative solid waste management scenarios. In this context, a solid waste management system model was established for Ankara Metropolitan Municipality and four different solid waste management scenarios were examined on this model. Scenario-1 considers the management system, which was in force before the new law. Scenario-2 considers the establishment of a transfer station to every peripheral district, Scenario-3 considers the establishment of a sanitary landfill to every peripheral district and Scenario-4 considers the establishment of sanitary landfills for grouped peripheral districts. The scenarios were analyzed economically and the costs that would occur for 20 years were compared over the net present value. Within the concept of sustainable development, Scenario-4 was selected as the best that brings the responsibilities of the

Law No. 6360. In order to implement the selected solid waste management scenario, the policy instruments needed by the Ankara Metropolitan Municipality were developed

Keywords: Solid Waste Management, Ankara Metropolitan Municipality, Law No 6360, Policies

ÖZ

YENİLENEN BÜYÜKŞEHİR BELEDİYE YASASI SONRASI ANKARA BÜYÜKŞEHİR BELEDİYESİNİN BELEDİYE KATI ATIK YÖNETİMİ İÇİN UYGUN POLİTİKA ARAÇLARININ BELİRLENMESİ

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30 Mart 2014 tarihinde 6360 sayılı yasanın yürürlüğe girmesiyle Büyükşehir Belediyelerinin sorumluluk sınırları il mülki sınırlarına genişletilmiştir. Bu genişleme Büyükşehir Belediyelerine katı atık yönetimini de barındıran çevre hizmetleri konusunda yeni sorumluluklar yüklemiştir. Bu çalışmanın amacı (a) yeni yasa ile belediyelerin katı atık yönetim görevinin layıkıyla yerine getirilmesi için ihtiyaç duyacakları politika araçları belirlemek ve (b) olası katı atık yönetim senaryo seçeneklerini incelemektir. Bu kapsamda, Ankara Büyükşehir Belediyesi için katı atık yönetim sistemi modeli oluşturulmuş ve bu model üzerinde dört farklı katı atık yönetim senaryosu incelenmiştir. Senaryo-1, yeni yasadan önce yürürlükte olan katı atık yönetim sistemini, Senaryo-2, her bir çevre ilçeye bir aktarma istasyonu kurulmasını, Senaryo-3, her çevre ilçeye bir düzenli depolama sahası kurulmasını, Senaryo-4 ise çevre ilçeler için oluşturulan gruplandırmalar için düzenli depolama sahalarının kurulmasını ele almaktadır. Senaryolar ekonomik olarak analiz edilmiş 20 yıl boyunca ortaya çıkacak maliyetler net bugünkü değer üzerinden karşılaştırılmıştır. Senaryo-4 6360 sayılı yasanın getirdiği sorumlulukları sürdürülebilir kalkınma konsepti içerisinde en iyi sağlayan senaryo seçilmiştir. Seçilen katı atık yönetim

senaryosunun uygulanabilmesi için, Ankara Büyükşehir Belediyesinin ihtiyaç duyacağı politika araçları geliştirilmiştir.

Anahtar Kelimeler: Katı Atık Yönetimi, Ankara Büyükşehir Belediyesi, 6360Sayılı Yasa, Politikalar

To my lovely daughter

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Even if you give up some things, life doesn't give up on you. It encourages you to walk on your way through people in your life. Along this six-year-long postgraduate study, life didn't let me go.

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CHAPTER 1

INTRODUCTION

Arising of environmental issues, perceiving of environmental issues as a problem and developing policies for solutions is a complex time period with multi-variables. Humankind regards nature as a gift since beginning, and uses its resources thoughtlessly. However nature and natural resources are not infinite as contrary to popular belief. The comprehension of limited renewing capacity of the nature took very long time for humankind. Basic damage of humankind to the nature was perceived as consuming however it was pollution. Every kind of consumption process, whether it is done for production, results with pollution. In today world; waste, which is the result of production and consumption cycle became a fundamental problem of communities.

Cities are increasingly becoming the center of living and production in global and national scale, for this respect, ascending consumption rates providing a growing solid waste problem. This situation increased incrementally just after the industrial revolution as a result of consumption community, that in parallel with the growing of production. Production, consumption and waste concepts are deprived to be solved together in scientific and technical perspective with environmental awareness’s.

Today's one of the major most pressing environmental problems is municipal solid wastes. Due to relatively low urban population and enough land space for landfilling, municipal solid waste not seen as an environmental problem until the mid of 20th century. But, with the huge increase in industrial production and the changes of consumption patterns of societies; the issue of MSW become a serious environmental threat. The adverse effects of solid wastes, on human health and the environment, are now well known all over the world (Arıkan, 2013).

The environmental policies was focused on reduction and purge of pollution, due to simple and misperceive of pollution, however policies rearranged after recognition of economic and social dimensions of pollution. Human Environment conference held in 1972 in Stockholm by United Nations was a result of the environmental pollution faced in the mid 20th century. Pollution became a threat to human health as a result of distortion of ecology. This situation required to rebuild relation between human and nature. Human accepted as a part of nature, not a conqueror, where two of which need together to be exist. This conceptual revolution effected policy makers also. The UN described development concept by the sustainability vision and set as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). This was the new description where the environment was set to the center of development. The obvious effects of this conceptual revolution were started to seen in cities, where human and environment was in strong relation. All kinds of polluter that is the end product of any kind of anthropocentric action, started to be controlled by ecocentric consideration. All polluters started to became respectful to all living and non-living things and renewing capacity of nature.

In this respect, governments started to form policies not only on the reduction of pollution but also on the prevention of pollution (Bilgili, 2012). From this point of view, environmentally friendly production and disposal methods have been developed to generate more environment friendly wastes. This development took place in developed countries at first, however developing countries were not able to accommodate these new approaches because of their limited financial resources. Waste management services are considered as an ordinary, economically unimportant service especially by local authorities of developing countries. Management of solid wastes, which are necessary to be collected and destructed by governments, brought economic burden to economical systems. Furthermore mistreatment of solid wastes means vanish of economical values. Developing countries give their priority to economical development (Orhan, 2014)

Global environmental problems need to act at international scale; however local authorities and actors are needed to apply solutions. It’s because issues arising from a local source and effecting citizens around source (Orhan, 2014). Therefore, local authorities need to be taken as source and solution of the problem.

All countries have different municipal solid waste management system according to their administrative strategies and waste characteristic. In general; local authorities and municipalities are responsible for solid waste management that has the major components of collection, transfer/transport and final disposal of wastes. These components may contain several processes such as sorting, uncontrolled dumping (wild dumping), controlled dumping or landfilling, incineration, composting, gasification, sorting, recycling, transportation etc. (Kısa, 2015). Municipalities are to provide the infrastructure and equipment needed for all these processes.

The By-Law on Waste Management[1] that is the major part of legislation towards successful solid waste management in Turkey, states that the sole responsibility for the management of municipal waste is on the municipalities. In addition, the Metropolitan Municipality Law[2] and the Municipality Law[3] define municipalities as responsible for providing all services regarding collection, transportation, separation, recycling, disposal and storage of solid wastes. In the past, metropolitan municipalities were responsible for the execution of solid waste management services within the borders of the urban area. But, with an amendment made in November 2012 to the Item 3 of the Metropolitan Municipality Law, service boundaries of the metropolitan municipalities extended to actual administrative borders of the metropolitan provinces. With this fundamental change, the responsibilities of the municipalities in solid waste management have increased drastically and it has become inevitable that this service be provided to all settlements within the provincial borders. This necessity requires metropolitan municipalities to assess the appropriateness of the existing solid

[1] By Law on Waste management Official Gazette, Date: 02.04.2015, No: 29314
[2]Metropolitan Municipality Law, Law No: 5216 Official Gazette, Date: 10.07.2004, No. 25531
[3]Municipality Law, Law No: 5393 Official Gazette, Date:03.07.2005, No. 25874

waste management system and, if necessary, to develop new approaches to solid waste management.

1.1. Purpose and Scope of the Study

The purpose of this study is to investigate how the Ankara Metropolitan Municipality's solid waste management system should be modified, and what technical, administrative, and social arrangements will be required and at what cost after the above-mentioned amendment made to the Metropolitan Municipalities Law numbered 6360[4],, which entered into force in 2012.

A simplified model for municipal solid waste (MSW) management system with five main components such as collection, transportation, accumulation, transfer and final disposal, generated. This model was used to develop four alternative collection and disposal scenarios to find out the optimum one.. The first scenario, Scenario-1 corresponds to the management system, which was in force before the new law. Scenario-2 considers the establishment of a transfer station to every peripheral district (PD), Scenario-3 considers the establishment of a sanitary landfill to every PD and Scenario-4 considers the establishment of sanitary landfills for grouped districts.

The projections and economic analyzes made in the study are based on the data of 2014 in order to understand the situation after the new law. Initially, considering the present and past population data obtained from TurkSTAT, population forecasting was done for all the districts of Ankara by applying five different methods (Exponential Growth Method, Least Squares Method, Compound Interest Method, Arithmetic Method and İlbank Methods). Then, based on the populations forecasted, the capital and operational costs for the four scenarios considered, were estimated. In estimating costs, unit cost data gathered from different relevant sources were used. Then, all the scenarios compared with respect to their net present values (NPV) to

[4] Law on establishment of metropolitan municipality and twenty seven districts in fourteen provinces and amending certain laws and decrees, Law No: 6360 Official Gazette Date : 06/12/2012 No: 28489

evaluating the best scenario and also for investigating the effect of the new law on the current MSW management system of Ankara Metropolitan Municipality

Among the results, policy instruments and management regulations for the implementation of environmental sensitive and the prominent option in economic issues have discussed.

In the context of the study, the separation alternatives, related to the recycling and reuse issues included in the solid waste management concept, were not studied due to lack of data.

CHAPTER 2

SOLID WASTE MANAGEMENT

2.1. What is waste?

In general sense “waste” can be defined as any kind of unusable material. The United Nation’s Glossary defines “waste” as follows;

"Wastes are materials that are not prime products (that is products produced for the market) for which the initial user has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose. Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. Residuals recycled or reused at the place of generation are excluded."(United Nations, 1997)

From this definition, it is clear that wastes recycled or reused at the place of generation are not classified as waste. Taking into account the value of waste as a resource, waste can be defined as “a resource that is not safely recycled back into the environment or the marketplace”. The by-Law on Waste Management, defines waste as “any substance or material that is discarded or that should be discarded into the environment by its generator or by its owner”.

2.2. What is Municipal Solid Waste?

United States Environmental Protection Agency defines municipal solid waste (also called trash or garbage) as “wastes consisting of everyday items such as product packaging, grass clippings, furniture, clothing, bottles and cans, food scraps, newspapers, appliances, consumer electronics, and batteries”. These wastes originate from, houses, schools, hospitals and commercial sources such as restaurants and small businesses, and do not include sludge from urban wastewater treatment plants, ash from combustion, waste from industrial processes, waste automobiles, or construction and demolition debris.

MSW includes different wastes from different sources with different proportions. Figure 1 represents the municipal waste composition in Turkey (TurkSTAT, 2011). As seen; 34 % is organic kitchen waste, 16% paper, 6% glass and 1 % metals. The rest is reported to have other combustible and non-combustible fractions. Taseli (2007) and Turan et al. (2009) approve this composition (Table 1). Accordingly, MSW in Turkey contains 45-50% organics, 25-30% recyclables and 15-20% others (Table 1). Organic fraction of MSW mainly contains kitchen wastes from houses, restaurants and hotels, plant leafs and residuals from gardens and yards. Recyclable fraction contains mainly cardboards, plastics (pet bottles), metals (tin- can) and glass. Other portion contains large items such as furniture, textiles, tires, electronics, batteries etc.

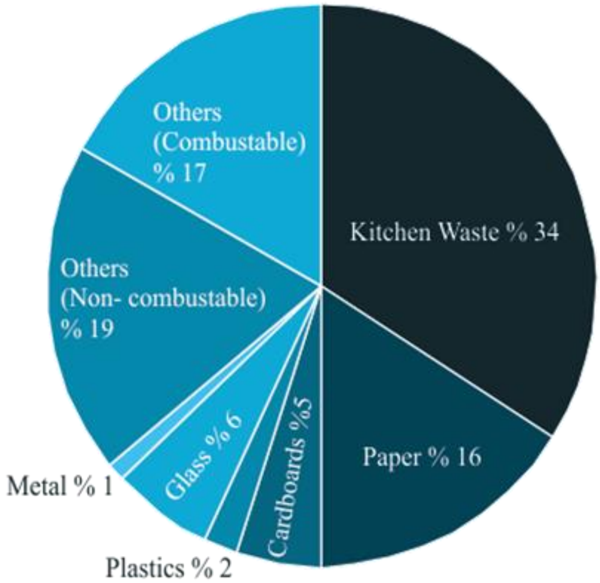

Figure 2.1 Municipal solid waste composition for Turkey (TurkSTAT 2011)

Table 2.1. *Generalized MSW composition for Turkey (Taşeli, 2007; Turan, Çoruh, Akdemir, & Ergun, 2009)*

	Percentage (%)	Explanations
Organics	45-50	Kitchen wastes, residuals from gardens and parks
Recyclables	25-30	Cardboard - metals - plastics - glass
Others	15-20	Furniture- textile - electronics - ash etc.

MSW generation rates are influenced by economic development, the degree of industrialization, public habits, and local climate. Generally, the higher the economic development and rate of urbanization, the greater the amount of solid waste produced. Income level and urbanization are highly correlated and as disposable incomes and living standards increase, consumption of goods and services correspondingly increases, as does the amount of waste generated. Urban residents produce about twice as much waste as their rural counterparts.

Additionally, the amount of MSW generation rate is influenced by economic development, consumption habits of citizens, the level of industrialization and local climate. Per capita MSW generation Solid in Turkey ranges between 0.8 to 2.0kg/day (292 to 730 kg/year)(Altuntop, Bozlu, & Karabıyık, 2014; Kanat, 2010; Metin, Eröztürk, & Neyim, 2003; Troschinetz & Mihelcic, 2009). According to Eurostat[5], for 2016, MSW generation in European Union (EU) countries varies considerably; from 777 kg per capita in Denmark to 261 kg per capita in Romania.

[5]http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wasmun&lang=en

2.3. What is Municipal Solid Waste Management?

Waste management not only deals with the produced waste, also considers the reduction of waste that is to be produced. It can be defined as all the activities required to manage waste from its generation to its final disposal. The relevant activities mainly include collection, transport, treatment and disposal of waste. Waste management also encompasses the legal and regulatory framework that relates to waste management and monitoring activities.

There exists a waste management hierarchy that can simply expressed by 3R rule, reduce, reuse and recycle, which is defined in the EU Landfill Directive (Figure 2.2). It does not end with recycling, it contains incineration, composting, and land filling (Taşeli, 2007).

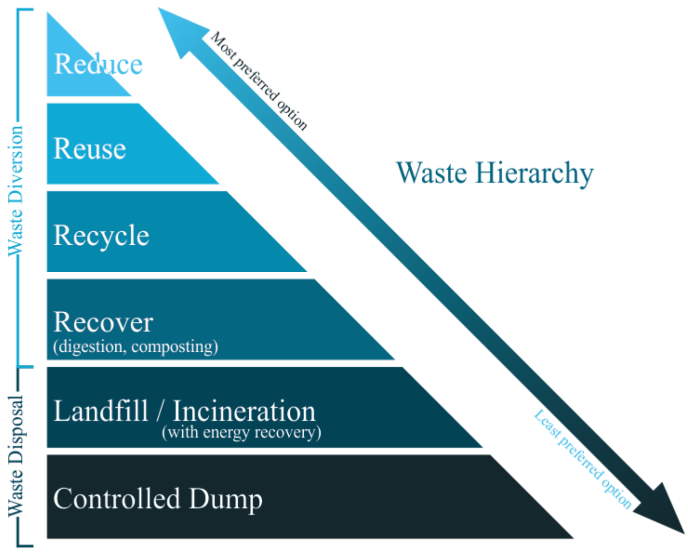

*Figure 2.2*Waste hierarchy (World Bank)

This hierarchy approach was improved to the end of life cycle of a waste by considering all component of waste. Hierarchy aims to reduce the volume and of waste going landfilling and to recover waste as much as possible.

The principles of waste hierarchy are not interlinked. All principles can be used solely; however, using all principles in a waste management system is the best goal.

Reduce / Reduction is a pre-production principle. It requires the re-design of goods, production procedures, packing and transportation to reduce quantities of waste generated.

Reuse is the during production or consumption principle to reuse of any kind of product for the same or new purpose without undergoing a physical change.

Recycling is the post-consumption procedure to reclaim valuable materials from final waste disposal back into the consumer market and contributes to considerable energy savings in the manufacturing of new products made from recycled feedstock (Özata, 2011).

Recover is the pre-disposal or post recycle principle especially for organic waste to composting or anaerobic digestion. The end product of composting is fertilizers and anaerobic digestion generates methane that can either be flared or used to generate heat and/or electricity.

Incineration of waste (with energy recovery) can reduce the volume of disposed waste by up to 90%. Incineration allows direct energy recover; however indirectly inefficient in terms of feedstock. It is best to use after principles above.

Landfilling is the cheapest method of disposal. Landfills are a common final disposal site for waste and should be engineered and operated to protect the environment and public health. Landfill gas can be recovered, including methane, to produce electricity. On the other hand, it is necessary to manage non-recyclable and noncombustible wastes and is the only actual waste "disposal" method in the hierarchy.

Controlled dump is a passive procedure where there is no pretreatment for the collected waste. It only provides the protection of the environment and public health.

Waste management can be provided by the integrated consideration of all approaches that can be used to solve waste problem (Kaya, 2013). Solid waste management approach includes both economic and environmental analyses (Banar, Cokaygil, & Ozkan, 2009).

2.4. Waste Management in Turkey

The history of legislation relating to municipal waste management in Turkey dates back to 1930 with the Municipalities Law numbered 1580[6]. According to this law, the settlements that have population more than 2000 are accepted as municipality. This law made the municipalities responsible for the management of solid wastes, protection of public health and improvement of living standards of citizens. Collection, recycling and deposition of wastes and cleaning of streets and roads were defined as the duties of the municipalities (Kaya, 2013; TCA, 2007). However, there were deficiencies in the implementation of this law due to some economical and administrative reasons. Until the mid of 2000's; some municipalities' were dumping their collected MSW to lowlands, seas, shores, and open areas without any pretreatment (Kanat, 2010), which is illegal.

This law had been supported with other laws, which are Public Health Law[7] 1593 published in 1930 and the Constitutional Law of 1982. The Constitutional Law of 1982 established a provision that *"every citizen is entitled with the right to live in healthy and stable environment."* in Article 56. The Environmental Law[8], which is a framework law; defined the responsible and authorized institutions and organizations,

[6] Municipality Law, Law No: 1580 Offical Gazette, Date: 14.04.1930 No: 1471
[7] Public Health Law, Law No: 1593 Offical Gazette, Date: 06.05.1930 No: 1489
[8] Environmental Law, Law No: 2872 Offical Gazette, Date: 08.11.1983 No: 18132

determined the processes for the implementation and established a punishment mechanism for the improper acts and defined the liabilities of the concerned authorities within the framework of the principle of "polluter pays" (Official Gazette, 1963).

Industrialization and improved living standards lead people to migrate to urban areas from rural areas resulting an increase in urban population. The Municipalities Law, numbered 1580, became inadequate to manage newly formed cities with populations more than 1 million. Thus, a new Metropolitan Municipality law[9], numbered 3030, was published in 1984. By this law, responsibilities of metropolitan municipalities with regard to solid waste management services were distributed among different authorities. The responsibility of building and operating solid waste handling facilities and controlled dumping areas was directed to metropolitan municipalities. On the other side, the collection of waste from source and the transportation to the dumping site were among the responsibilities of district municipalities.

In the Sixth Five-year' Development Plan prepared for the period of 1990-1994, the targets and policies regarding the disposal and storage of MSW, storage sites, site selection and transportation were established. However, as the practices were not satisfactory, the accident of the Ümraniye, Hekimbası open dumpsite happened in 1993 in İstanbul, which was caused by the explosion of landfill gasses compressed within the dumping area, caused the death of 39 people (Kocasoy & Curi, 1995). This accident became the starting point for Turkey to develop a scientific perspective in handling the solid waste problem. Since the beginning of the 2000's, legal arrangements have been made in line with the environmental directives of the European Union within the scope of European Union harmonization process. Within this perspective; in the years 2004 and 2005, the laws numbered 5216 and 5393 were

[9] Law on the Adoption of Amended Decree Law on the Management of Metropolitan Municipalities, Law No:3030 Offical Gazette Date :09.07.1984 No: 18453

enacted, respectively. These laws contained more detailed information about the environmental services to be given by the municipalities.

The Law numbered 5216 introduced a new perspective in the construction of the municipalities. Within this new perspective, environmental services to be given by the municipalities have been redefined, so; the solid waste management system has also changed.

The metropolitan areas, which have a high transportation and communication network, are considered as a big market in the global economy; the center of the commercial center and the engine of the national economy (Zengin, 2014). Metropolitan cities are large cities and settlement areas consisting of many satellite towns surrounding them. In this sense, the metropolitan areas cover a large basin. This extensive watershed appraisal will be an important assessment that shapes and renders the law.

The authority and financial resources required for solving the urban troubles have been shared among many local administrative units. In the execution of services, there are problems originating from incompatibilities among different plans developed by different authorities. As is well known, there are many administrative units which are authorized. As a result, resources are wasted (Zengin, 2014), and more importantly; relevant services cannot be executed properly.

Item 7 of the Law 5216 was giving details regarding the duties, authorities and responsibilities of Metropolitan municipalities in terms of municipal SWM. The related section of the 7th item is as follows;

> *To enable protection of the environment, agricultural areas and water basins according to applicable sustainable development plan; to undertake planting of trees; to designate storage areas for excavated earth, debris, sand and pebbles, coal and wood sales and storage places, to take measures avoiding environmental pollution during transport of the same; to prepare refuse management plan for the greater city , or to delegate other to undertake this task; excluding the works relating to*

accumulation of the wastes in the well and transport to the transfer places, to undertake services relating to recycling, storage and disposal of wastes , to establish and operate or let others to establish and operate plants for this purpose; to perform the services relating to industrial and medical refuses, to establish and operate or let others to establish and operate plants for this purpose; to undertake collection and purification of refuses discharged from sea carriers by preparing regulations on this subject(Official Gazette, 2004).

Briefly, municipalities were responsible not only for the management of MSW but also the enforcement and monitoring of the related regulations and laws. In addition; the metropolitan municipalities were obliged to build infrastructures and structures necessary for solid waste management services in line with the law.

Item 15th of the Municipality Law numbered 5393 that came into effect in 2005 emphasized the expression that "to render all kinds of services related to collection, transportation, decomposition, recirculation, removal and storage of solid wastes. are duties of the municipalities".

The Law No. 6360, which came into force after the March 30th local elections in 2014 is the starting point of the topic of this study. This law, which was partly about the establishment of fourteen new metropolitan municipalities, was put into force with similar reason as the Law numbered 5216. The reason for this law is declared as to increase effectiveness and efficiency in public administration in a globalized world. It is necessary to meet the growing expectation of the citizen and to ensure higher participation in the management process, to make plans in a holistic regional dimension instead of fragmented plans, to prevent resource waste arising from the lack of managerial capacity of low local government units and lack of coordination between local administrations. In addition to these general statements, it has been argued that it is necessary to disseminate this practice by arguing that the application of the confinement of property boundaries to the metropolitan municipality boundaries in Istanbul and Kocaeli has improved the integrity and efficiency of services.

According to new legal framework, district municipalities that are within the borders of metropolitan municipalities, are only responsible for the collection and transportation of the solid wastes to the final disposal site. However, other district municipalities are responsible for the collection, transportation and final disposal MSW.

In Turkey, there are 1396 municipalities, of which 31 are metropolitan municipalities. Among 1396 municipalities, a total of 1391 provides solid waste management services. However, there is no information regarding the reason why the remaining 5 municipalities do not provide solid waste services. As final disposal facilities, there are 113 sanitary landfills, 4 composting plants (3 of which are being actively operated), and 4 incineration plants (TURKSTAT, 2015). Most widely used collection method is curbside pickup in Turkey. This method is especially used at places where the municipal SWM system is developed. Additionally, in some municipalities with low population and with poor MSW services, community bins system is in use.

Table 2.2. *MSW disposal methods of Turkey (ton/year) (TurkSTAT 2015)*

Disposal Method	2004	2006	2008	2010	2012	2014
Open Burning	101,623	246,548	239,291	133,876	104,751	4,280
Dumping to other Municipal LF	788,104	565,598	347,943	418,933	447,635	187,450
Municipal LF	11,832,021	11,822,158	10,052,659	8,754,470	8,216,626	7,521,922
Metropolitan M. LF	3,795,643	2,553,398	2,276,540	1,827,750	1,106,706	2,226,228
SLF	7,001,523	9,428,323	10,947,437	13,746,876	15,484,196	17,807,424
Buried	426,474	144,459	100,486	34,295	94,315	7,320
Composted	350,744	254,929	275,737	194,452	154,652	126,485
Dumped to waterland	154,735	69,828	47,685	43,965	33,409	15,770
TOTAL	**24,450,867**	**25,085,241**	**24,287,778**	**25,154,617**	**25,642,290**	**27,896,879**

According to the data of TurkSTAT, the daily waste generation per capita was approximately 1.08 kg (Figure 2.3) and the total collected MSW was 28.010.721 tones/year in 2014(Figure 2.4).

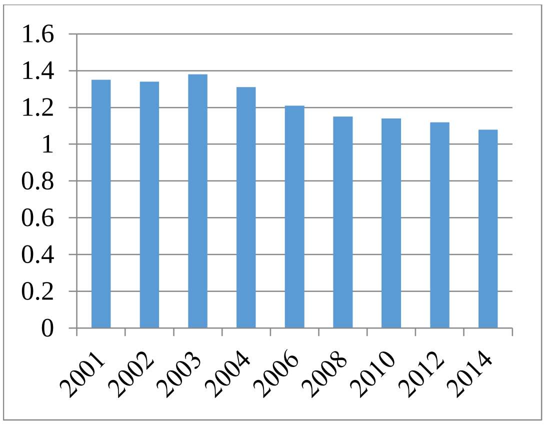

Figure 2.3. MSW per Capita in Turkey (kg/day)

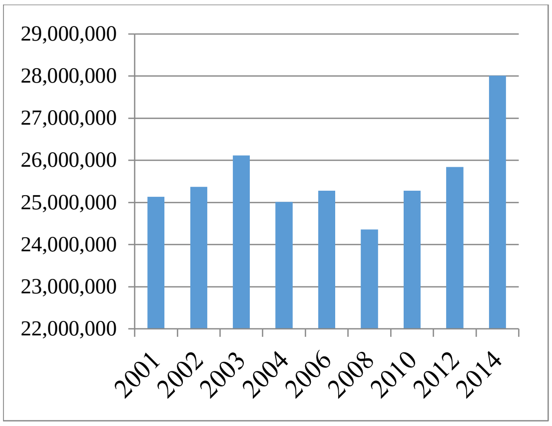

Figure 2.4. Collected MSW in Turkey (ton/yr)

Turkey was classified as an economically upper-middle income country by World Bank in 2012. On the other hand, United Nations classifies Turkey as an economically developing country. Turkey is the 18th largest economy of the world and its growth rate is approximately 3.5% per year (WORLDBANK, 2016). According to a report by the World Bank (WORLDBANK, 2016), the average daily per capita solid waste generation amount for the Upper Middle income country group, in which Turkey was located, is 1.16 kg. This report also foresees an average per capita solid waste generation of 1.6 kg for this income group, in 2025 (Hoornweg, Bhada-Tata, & Joshi-Ghani, 2012).

CHAPTER 3

SOLID WASTE MANAGEMENT IN ANKARA

3.1. Development of Ankara Metropolitan municipality

Figure 3.1. Geographical location of Ankara City

Ankara City is the capital of Turkish Republic and the second largest city with its 5,150,000 total population and 25,437 square kilometers surface area (Directorate of Environment and City Planing, 2014). It is located in Central Anatolia Region (Figure 3.1). The city was announced as the capital in October 13th 1923. In that year, the total population of the city was approximately 30,000. Over time, the city grew, and the population reached up to 227000 in 1945 (*Figure* 3.2). Later in the year of 1984, the city was announced as a metropolitan municipality, because the administration of populated cities become more and more difficult to overcome.

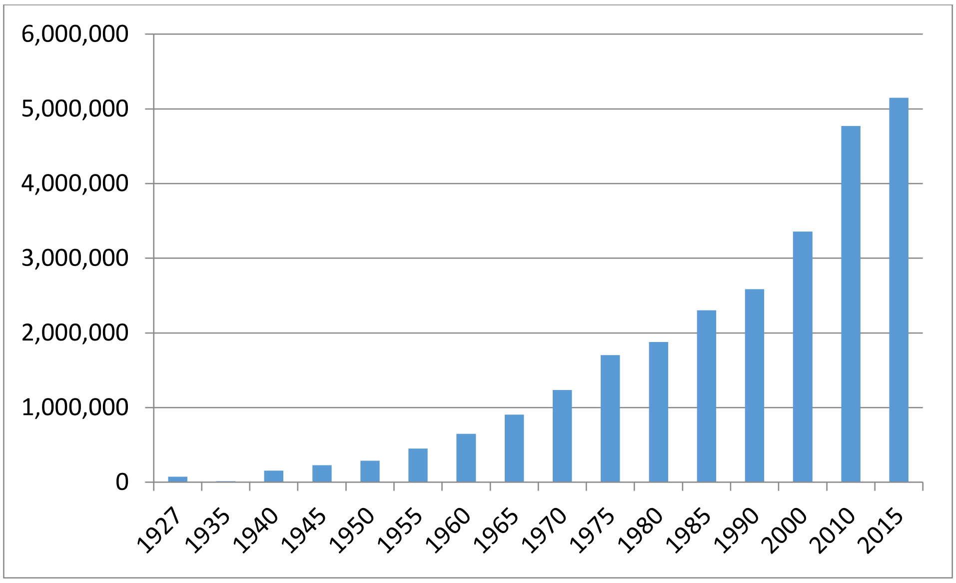

Figure 3.2 Population growth of Ankara

The city center of Ankara locates approximately at North east of the territorial boundaries of the City (Figure 3.3). There are 25 district municipalities and 672 villages in the City of Ankara. Ankara Metropolitan Municipality reached its present jurisdiction in 30 years gradually. Within this time frame, it has been expanded for four times; and reached its last status in 2014. Altındağ, Çankaya, Yenimahalle, Keçiören and Mamak districts were included within the metropolitan municipality in 1984 (Official Gazette, 1984). Sincan included in the area of jurisdiction of Ankara by the decision of the Cabinet of Ministers no 88/12721 dated 08 March 1988. Etimesgut included by Law 3644[11] in 1990 and a year later Gölbaşı, where owned district organization structure in 1991, included in the area of jurisdiction of Metropolitan Municipality. By the year 2004; Çubuk, Akyurt, Kalecik, Kazan, Ayaş, Pursaklar, Bala and Elmadağ municipalities were included (Official Gazette, 2004). Finally, the last enlargement come into force, that is the main subject of this paper, Evren, Şereflikoçhisar, Haymana, Güdül, Nallıhan, Beypazarı, Polatlı, Çamlıdere and

[11] Law On The Establıshment Of 130 Dıstrıcts Law No: 3644 Official Gazette Date 20.05.1990 No:20523

Kızılcahamam districts were included by the law no 6360 (Official Gazette, 2012)(Figure 3.3).

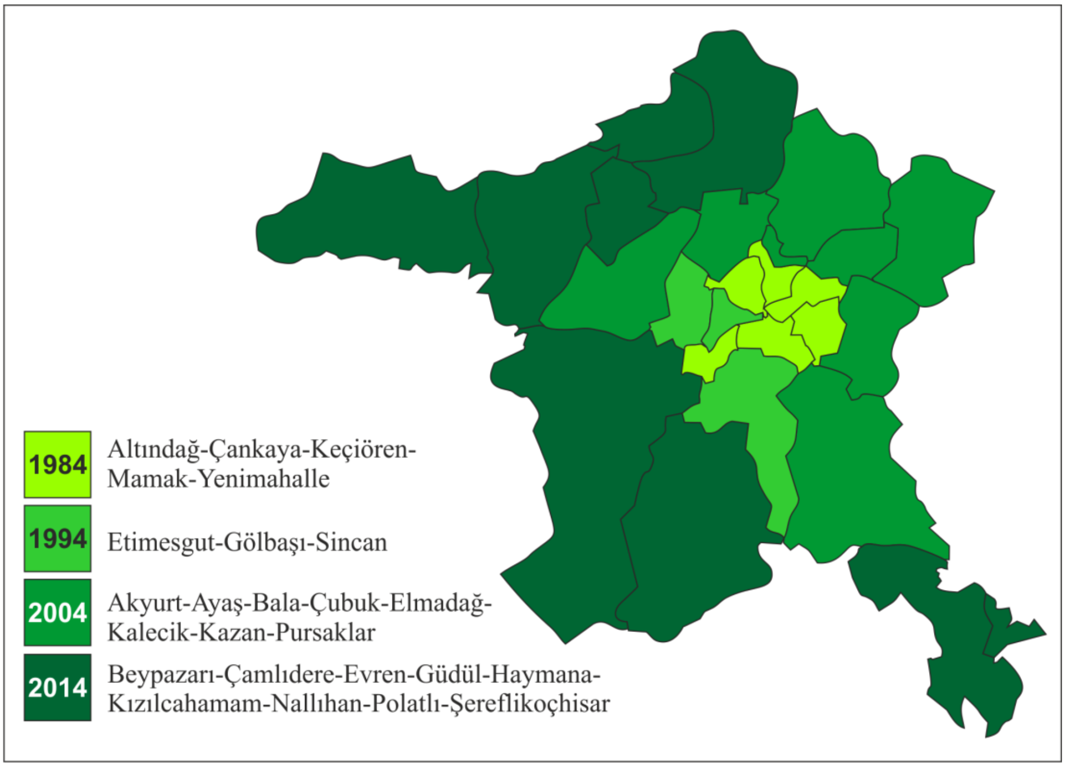

Figure 3.3. Growth of Metropolitan Municipality area of jurisdiction since 1984

As can be seen in Figure 3.3, the authority borders of the Ankara Metropolitan Municipality have gradually expanded within the last 30 years. In 2014, with the new Metropolitan Municipalities Law (numbered 6360), metropolitan municipality borders overlapped with provincial borders and the entire population living in the all districts of Ankara, has become under the responsibility of the Metropolitan Municipality. With the recent legislation, the rural and urban discrimination within the population has completely disappeared and the whole population has started to be accepted as urban. However, it will take time for urbanization to take place in the known sense. There is only a road infrastructure that enable municipal services to reach the household in the city.

3.1.1. History of Waste Management in Ankara

In this section, the history of the SWM system of Ankara is described to form a background to the present study, giving a special attention to the new Metropolitan Municipality Law.

Historically, MSW of the Ankara City has been dumped to Tuzluçayır Dump Site until the 1980's. After the mid of 1980's,Tuzluçayır Dump Site was closed down due to insufficient capacity and the Mamak Dump Site was taken into service (TCA, 2007). In early 2000's, the Mamak Dump Site had been rehabilitated and started to serve as a sanitary landfill. Today, this landfill is still in use and receives the MSW from the central district municipalities (CDMs) of Ankara which are Çankaya, Mamak, Altındağ, Keçiören, Yenimahalle, and Gölbaşı.

After the Law numbered 5126, the district municipalities of Ankara can be examined under two groups. One of these groups is the CDMs, which are within the boundaries of the provincial municipal administration, and the other is the peripheral municipalities. All municipalities have their own solid waste collection methods. But, if it is required to generalize; central districts have adopted the door to door collection method. On the other hand, the surrounding or peripheral district municipalities (PDMs) have developed different methods according to the generated waste characteristics. These are community bins, curbside pick-up, hauled container or stationary container methods. The CDMs are responsible for collecting waste and transporting waste to the disposal site. Disposal of waste is the responsibility of the metropolitan municipality. The PDMs are responsible for all waste collection, transportation and disposal processes.

In the CDMs of Ankara, waste pick up is done at evening and night times, when street traffic density is low. Collection is done by garbage trucks, which are specifically designed with hydraulic press mechanism to compress the collected waste and to haul it directly to the landfill or to transfer stations. In each garbage truck, there are two workers and a driver. In the past, there was a transfer station in Yüzüncüyıl - Çankaya that was used by the Çankaya CDM. However, this transfer center was closed in the scope of master plan of Ankara province in 2011 by considering the malodors and health conditions (Directorate of Environment and Forestry, 2011). There are two sanitary landfills in Ankara, which are located in Mamak and Sincan –Çadırtepe.

Some brief information about Mamak and Sincan-Çadırtepe landfills are given below.

- Mamak Landfill was the largest uncontrolled landfill or dump site of the City of Ankara. In 2007, the Mamak Site has been rehabilitated: A methane gas collection system and a composting facility were constructed and put into operation. In addition, a power plant was constructed on the site to convert captured methane gas into electricity providing a power of 24.5 megawatt/ hour. In addition; a packaging waste collection and separation system, a plastic waste recycling facility, a demolition waste recycling facility were built on the site to improve the overall waste management system. Today; the MSW of Çankaya, Mamak, Altındağ, Keçiören, Yenimahalle, Gölbaşı districts goes to the Mamak Site. According to the statistical data, 750 - 800 tons/day of waste is handled in this landfill site.
- The Sincan Çadırtepe Landfill Site has the second largest landfill of the City of Ankara, which was built in 1999, as an engineered landfill. This waste disposal site is also home to a packing waste collection and separation facility, and a power plant with the installed electricity production capacity of 14.1 megawatt/hour. The MSW of Etimesgut, Sincan and Kazan municipalities ends up in the Sincan-Çadırtepe Landfill Site since 2007.

The PDMs collect waste from waste containers/bins and transporting them to their own dumping areas. All the peripheral municipalities of Ankara dump their MSW onto uncontrolled dump sites where there are no waste segregation facilities. The rest of the MSW management system is similar to that of the CDMs.

There exists a third group of local settlements with regard to SWM, which are "villages". According to the Law numbered 5302[12], Special Provincial Administrations are responsible for the collection and transportation of the wastes

[12] Special Provincial Administration Law, Law No: 5302 Official Gazette Date 04.03.2005 No:25745

from villages to the nearest municipal landfills. In some villages, village citizens dump their waste themselves to open, unused lands for final disposal.

The above-mentioned actors are the legal shareholders of the MSW management system. However, there are also illegal ones; scavengers or waste pickers, who do the scrap collection for reusable or recyclable materials. These waste pickers scrap the wastes collected in bins from homes and institutions to collect card boards, papers, plastics and similar to sell. Some scavengers reserve the waste for food. In Ankara, waste scavengers are not legal and organized group of people. All the scavengers in Ankara, work under unhealthy conditions, without using gloves, masks or protecting clothes. The materials collected are subjected to some kind of intermediate processing; such as separation, washing, and drying. The reclaimed materials were then sold to refuse dealers, who further separate the materials and sell them to appropriate processing/remolding mills and factories. It was estimated that, in Ankara, approximately 10–15% of MSW is recycled by scavengers (Kırer, 2016).This unregistered collection and transformation activity adversely affects the healthy operation of the solid waste disposal facilities, which are expected to finance itself and are expected to perform at low wages due to the scale economy.

3.1.2. Waste Generation and Composition in Ankara

According to the statistical data of 2014, average per capita MSW generation is 1.30 kg per day in Europe and 1.08 kg per day in Turkey. The generation rate in Turkey is below the European average waste generation rate. Ankara is generating approximately 7.5% of the total MSW of Turkey. Average per capita MSW generation in Ankara is 1.1 kg/day. This generation rate of Ankara is slightly above the Turkey's average according to TURKSTAT. The MSW generation rate data of Ankara is compared with those of the other provinces of Turkey in *Table 3.1*.

Table 3.1 *Municipal solid waste generation of the provinces in Turkey*

Province	Amount of waste per capita (kg/capita-day)	Province	Amount of waste per capita (kg/capita-day)	Province	Amount of waste per capita (kg/capita-day)	Province	Amount of waste per capita (kg/capita-day)
Adana	0.86	Çanakkale	1.46	K.maraş	0.80	Osmaniye	1.00
Adıyaman	1.05	Çankırı	1.39	Karabük	1.15	Rize	0.97
Afyonkarahisar	1.26	Çorum	1.22	Karaman	1.21	Sakarya	1.00
Ağrı	1.22	Denizli	1.02	Kars	1.61	Samsun	0.93
Aksaray	1.01	Diyarbakır	1.02	Kastamonu	1.72	Siirt	0.93
Amasya	1.00	Düzce	1.49	Kayseri	0.87	Sinop	1.41
Ankara	*1.10*	*Edirne***	*1.81*	Kırıkkale	0.86	Sivas	1.12
Antalya	1.27	Elazığ	1.60	Kırklareli	1.30	Şanlıurfa	1.01
Ardahan	1.68	Erzincan	1.51	Kırşehir	1.22	Şırnak	1.09
Artvin	1.00	Erzurum	0.80	Kilis	1.20	Tekirdağ	1.20
Aydın	1.16	Eskişehir	0.93	Kocaeli	0.91	Tokat	0.82
Balıkesir	1.37	Gaziantep	0.85	Konya	1.03	*Trabzon**	*0.67*
Bartın	1.30	Giresun	1.12	Kütahya	1.13	Tunceli	1.15
Batman	0.83	Gümüşhane	0.97	Malatya	0.96	Uşak	1.18
Bayburt	1.16	Hakkari	0.72	Manisa	1.25	Van	0.99
Bilecik	1.21	Hatay	0.72	Mardin	1.09	Yalova	1.20
Bingöl	1.21	Iğdır	1.31	Muğla	1.73	Yozgat	1.14
Bitlis	0.78	Isparta	1.23	Muş	0.88	Zonguldak	1.21
Bolu	1.67	İçel	1.04	Nevşehir	1.40	*Türkiye*	*1.08*
Burdur	1.17	İstanbul	1.16	Niğde	1.12		
Bursa	1.00	İzmir	1.12	Ordu	0.80		

*The lowest value ** The highest value

The per capita solid waste generation in Ankara was examined in the light of the data presented in *Table 3.1*, independent of the population and other variables. The highest generation rate is 1.81 kg/day/person in Edirne and the lowest is 0.67 kg/person/day in Trabzon. This variation may originate because of geographical and climatic differences, consumption habits, collection methods, quality of MSW management service, education level and gross domestic product (GDP). It is required to understand the parameters associated with the solid waste amounts given in *Table 3.1* and to establish a basis for the solid waste estimates to be provided for Ankara in the study. Shekdar (2009) says that the amount of MSW production is proportional to the economic level of society. From this point, GDP of all cities in Turkey was compared with respect to solid waste generation rates. In cities with high GDP, it is expected that daily solid waste production per capita will be high. When *Table 3.1* and are compared, it is seen that high and low GDP values were not overlapping with solid waste generation (SWG) per capita.

Table 3.2 *Gross Domestic Product of the cities in Turkey*

Province	GDP per Capita TL	Province	GDP per Capita TL	Province	GDP per Capita TL	Province	GDP per Capita TL
Adana	19,381	Çanakkale	26,634	K.maraş	15,764	Osmaniye	15,878
Adıyaman	13,549	Çankırı	19,033	Karabük	21,064	Rize	22,329
Afyonkarahisar	18,219	Çorum	17,084	Karaman	24,452	Sakarya	24,359
Ağrı*	***8,486***	Denizli	24,772	Kars	12,433	Samsun	19,224
Aksaray	18,229	Diyarbakır	12,800	Kastamonu	19,917	Siirt	12,232
Amasya	18,916	Düzce	24,032	Kayseri	23,129	Sinop	17,134
Ankara	***36,680***	Edirne	23,346	Kırıkkale	19,594	Sivas	18,480
Antalya	29,693	Elazığ	16,946	Kırklareli	27,870	Şanlıurfa	9,773
Ardahan	13,909	Erzincan	22,948	Kırşehir	17,620	Şırnak	12,186
Artvin	21,999	Erzurum	15,442	Kilis	13,648	Tekirdağ	33,259
Aydın	19,121	Eskişehir	28,824	Kocaeli	43,521	Tokat	14,093
Balıkesir	22,197	Gaziantep	18,788	Konya	20,981	Trabzon	22,073
Bartın	17,275	Giresun	14,967	Kütahya	19,799	Tunceli	22,301
Batman	11,794	Gümüşhane	18,356	Malatya	15,207	Uşak	21,916
Bayburt	15,854	Hakkari	11,660	Manisa	24,300	Van	9,913
Bilecik	32,602	Hatay	16,702	Mardin	13,286	Yalova	28,517
Bingöl	12,811	Iğdır	13,734	Muğla	27,061	Yozgat	15,688
Bitlis	12,065	Isparta	20,975	Muş	11,734	Zonguldak	18,448
Bolu	30,673	İçel	21,217	Nevşehir	18,979	***Türkiye***	***26,489***
Burdur	23,342	***İstanbul*****	***43,645***	Niğde	17,491		
Bursa	29,946	İzmir	31,179	Ordu	14,575		

*The lowest value ** The highest value

The results obtained from this comparison is not as significant as that of Guerrero et al. (2013) who reported that solid waste production is directly related with GDP and the projections and calculations for the amount of solid waste in Ankara will not be made on a GDP basis.

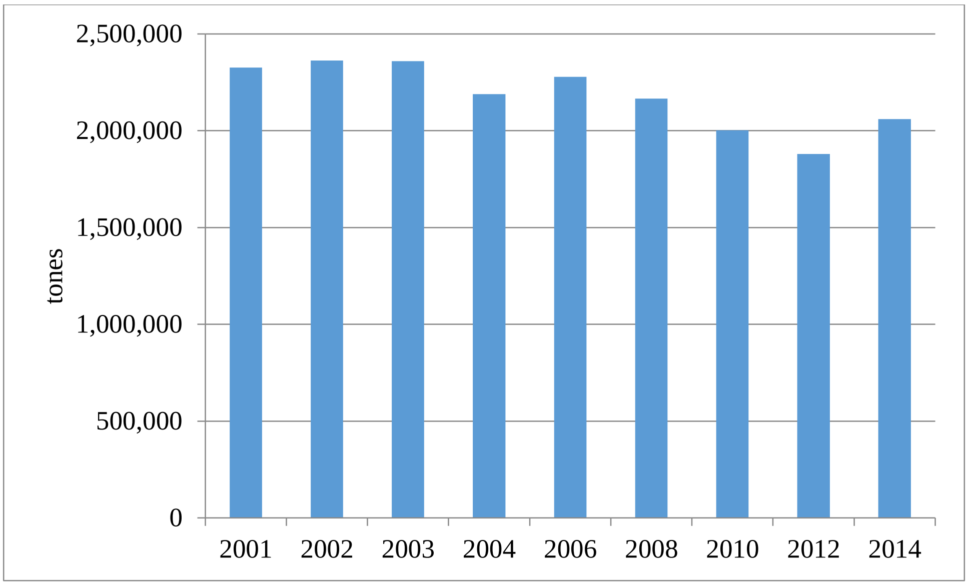

Figure 3.4 Total waste generation of Ankara by years (tones / year) (TURKSTAT, 2014)

The total waste generation of Ankara in the last decade is seen in . As can be seen in the graph, solid waste production has gradually decreased until 2012, however there observed an increase by the year 2014. Although the reason for this increase is not clearly known, it is thought that the SW produced by the PDs after 2012 might be included in the calculation. Under these circumstances, it would be sufficient to relate the amount of solid waste in Ankara directly to the population and make a population-based observation.

Although this study is specifically carried out for Ankara, the Law numbered 6360 covers thirty metropolitan areas in Turkey. For this reason, was prepared in order to compare the population, surface area and solid waste amounts of Ankara with the other 29 big cities. The table is based on TURKSTAT 2014 data.

Table 3.3 *Metropolitan Municipalities and the data on their area, population and MSW Generation (TURKSTAT, 2014)*

City	Area, (km^2)	Population	Population Density, (person/km^{2})	MSW generated, (tones/year)	Amount of waste per capita (kg/capita-day)
Adana	14,125	2,201,670	158	667,480	0.86
Ankara	25,437	5,346,518	218	2,059,306	1.10
Antalya	20,909	2,328,555	112	1,015,827	1.27
Aydın	7,943	1,068,260	136	431,480	1.16
Balıkesir	14,272	1,196,176	84	536,379	1.37
Bursa	10,882	2,901,396	278	1,010,853	1.00
Denizli	11,861	1,005,687	86	360,924	1.02
Diyarbakır	15,272	1,673,119	111	566,687	1.02
Erzurum	25,355	762,021	30	178,669	0.80
Eskişehir	13,925	844,842	61	271,520	0.93
Gaziantep	6,887	1,974,244	290	584,017	0.85
Hatay	5,867	1,555,165	267	392,670	0.72
İçel	15,620	1,773,852	115	637,356	1.04
İstanbul	5,313	14,804,116	2 849	6,064,688	1.16
İzmir	12,007	4,223,545	352	1,659,986	1.12
K.maraş	14,525	1,112,634	78	308,752	0.80
Kayseri	17,170	1,358,980	80	416,541	0.87
Kocaeli	3,623	1,830,772	507	573,414	0.91
Konya	41,001	2,161,303	56	788,506	1.03
Malatya	12,146	781,305	66	263,673	0.96
Manisa	13,269	1,396,945	107	619,131	1.25
Mardin	8,858	796,237	90	300,087	1.09
Muğla	12,974	923,773	72	536,462	1.73
Ordu	5,952	750,588	126	186,064	0.80
Sakarya	4,878	976,948	202	339,826	1.00
Samsun	9,352	1,295,927	143	369,816	0.93
Şanlıurfa	19,451	1,940,627	103	574,972	1.01
Tekirdağ	6,339	972,875	154	396,813	1.20

Trabzon	4,662	779,379	167	186,260	0.67
Van	21,334	1,100,190	57	380,983	0.99

As can be seen from the table, there are cities with population densities lower than that of Ankara. When the geographical area covered by these provinces are considered as sole numerical values regardless of the geographical properties such as topography, terrain, location of the urban settlement in the province, Ankara being with the second largest area, appears to have more serious challenges with regard to solid waste services to be provided.

3.1.2.1. Composition of MSW in Ankara

There are limited number of studies available in the literature with regard to the composition of MSW from the city of Ankara. The most recent study is the one by the Ministry of Environment and Forestry carried out in the year of 2006. The results of this study are given in Table *3.4*. These data could not be used for the analyzes and calculations made within the scope of this study. Because the data does not reflect the solid waste characteristics of the districts connected to Ankara metropolitan municipality in 2014 by Law No. 6360. In other words, the study conducted by the ministry only covers the data of Mamak, Yenimahalle, Gölbaşı, Çankaya, Etimesgut, Kazan, Sincan, Keçiören, Altındağ and Beypazarı municipalities which were within the area of jurisdication of the Ankara Metropolitan Municipality in 2006.

Table 3.4 *Waste Composition of Ankara (Ministry of Environment and Forestry 2006)*

Waste composition	Percentage (%)
Organic	55.00
Paper	0.57
Glass	0.55
Metal	0.54
Plastic	5.00
Other	38.34

Information regarding the solid waste composition of the surrounding districts was needed to be used in the economic analysis to be carried out during the study, but no work on this subject was achieved. On the other hand, three sub-regions that the Ankara Development Agency determined according to economic activities for Ankara City gave an idea on this issue (Figure 3.5).

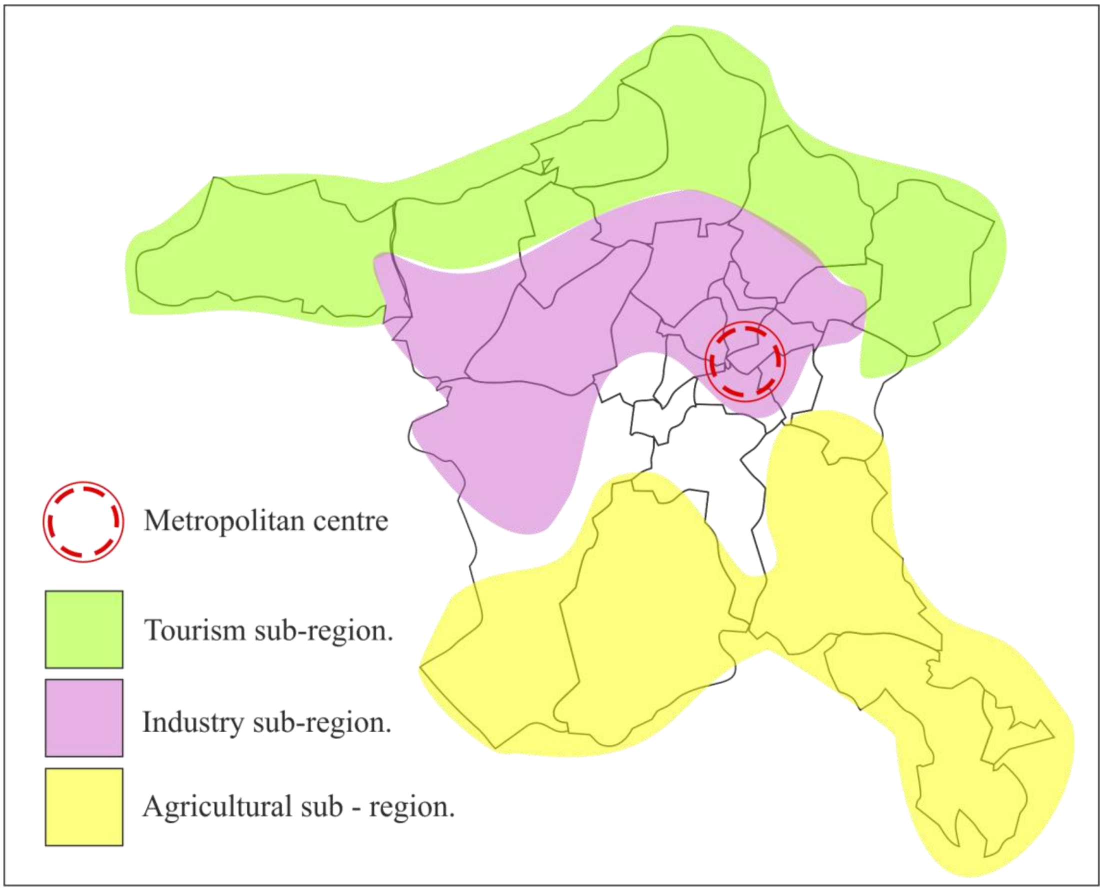

Figure 3.5 Sub-regions of Ankara (Redrawn from Ankara Development Agency, 2014)

As seen in Figure 3.5, the districts in the north of Ankara were defined as tourism sub-districts and the districts in the south were defined as agricultural sub-districts. The third sub-region was the industrial sub-region, which was defined to include the Ankara City center. It was possible to have an idea about the general characteristics of the solid waste to be produced in these regions by looking at the economic activities and livelihoods of the regions, but the obtained information was not suitable for use in the economic analysis in the study. It is easy to say that tourism sub-region is prone to generate more household waste, additionally this generation is season depended.

Total MSW generation of this sub-region increases during tourism seasons. Agricultural sub-region, which covers the south districts of Ankara, is more prone to produce agriculture originated organic waste.

Finally, the industrial sub-region is prone to produce more packing waste, which is rich in cardboards, papers, and plastics. Industrial activities also generate other kinds of wastes such as chemicals, sawdust, inorganics etc.; however these wastes are not subject of this study.

The involvement of the PDMs to the MSW management system of Ankara made difficult the inferences about the actual solid waste composition of the whole city according to above mentioned composition data and regional activities. For this reason, the solid waste composition found in the data of the Ministry of Environment and Forestry for the year 2006 has been valid for the whole city. Although the said data does not contain solid waste data of the PDMs covered by the metropolitan municipality after the Law numbered 6360 and it does not appear to be up to date, it is thought that the effect of the environmental districts on the solid waste composition will be low when the population size and development levels are considered.

3.1.3. Current Waste Management in Ankara

According to TURKSTAT data, the amount of MSW collected during the year of 2014 in Ankara was 2,059,306 tons. Based on a total population of 5,150,000; daily solid waste production per capita in Ankara is calculated as 1.1 kg.

Figure 3.6 shows the location of the landfills in the Ankara City. As shown in the figure, all district municipalities, which are not covered before by the Metropolitan Municipality Law, have their own uncontrolled landfills or dump sites. The total number of uncontrolled landfills is 15. The blue colored landfill is the Mamak Landfill Site which is rehabilitated in 2006. The green ones are the controlled landfills, Sincan and Şereflikoçhisar. The Şereflikoçhisar Landfill Site was built according to the

Conservation of Wetlands Legislation (Official Gazette, 2014). However, the facility in Şereflikoçhisar is not in use because of lack of technical capacity. This solid waste disposal facility is currently being used as an uncontrolled landfill.

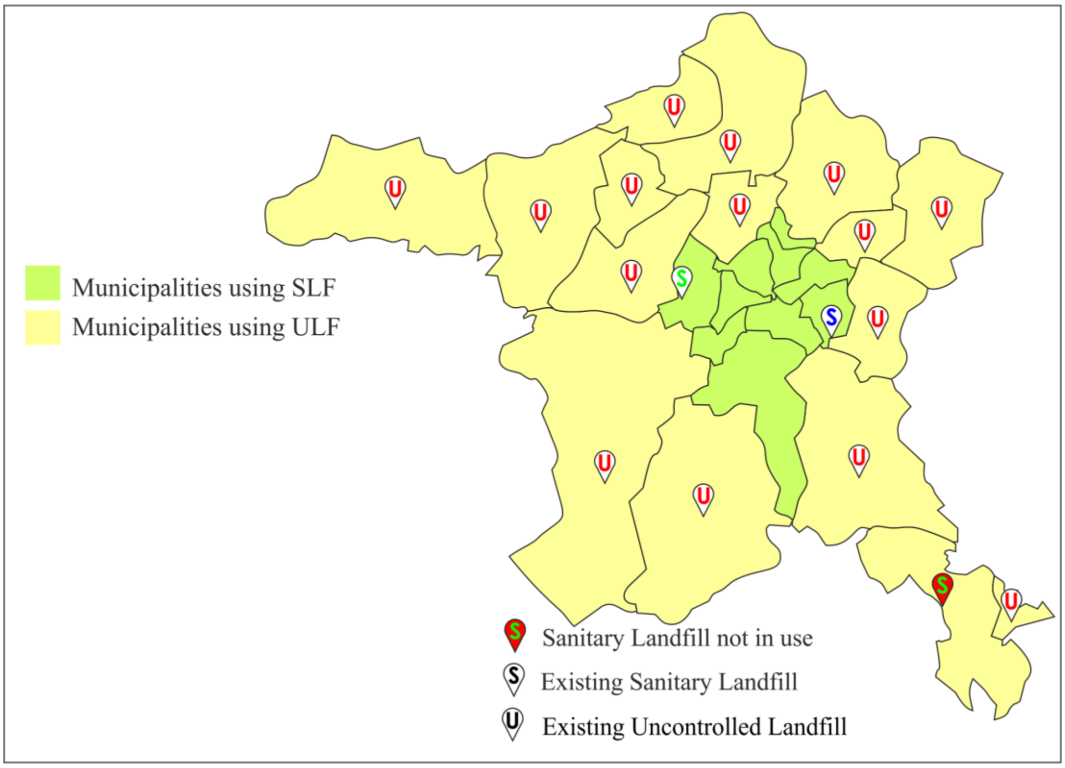

Figure 3.6 Location of landfills within borders of Ankara City. (Red: Uncontrolled (wild) Landfills Blue: Rehabilitated Landfills Green: Controlled Landfills)

Today, Ankara Metropolitan Municipality is responsible for disposal of waste of 25 district municipalities, which cover 672 neighborhoods. These neighborhoods were villages before the revised Metropolitan Law. All these neighborhoods and districts are scattered to the 25,437 km^2 surface area of city, however there are only three engineered landfills SLF, two of which are at around city center, and the other one is out of operation.

Figure 3.7. Districts of Ankara with distances (CESR 2013)

Current MSW management system of the Ankara City is not a planned, but a self - adapting system. According to the Municipality Law 6360, all the district municipalities are only responsible for collecting and transferring the solid waste to disposal site. Additionally, Ankara Metropolitan Municipality is responsible for disposal of waste, collected by DMs. However, today every district, which are not within the border of the Ankara Metropolitan Municipality, are dealing with their own waste. In other words, nine new districts are still acting same as before and dumping their waste to uncontrolled landfills. Additionally, new neighborhoods (old villages) are still collecting and dumping their wastes themselves.

Ankara Metropolitan Municipality plans to dispose of solid wastes collected in municipal municipalities, which are under its responsibility after the law, by bringing them to the facilities in Mamak and Sincan-Çadırtepe landfills. Within this scope, the Ankara Metropolitan Municipality has considered to build transfer stations to peripheral municipalities that are under its responsibility. The solid wastes collected in the districts will be transported to the facilities located near the city center via trailers after they are collected at the transfer stations. In this framework, establishing transfer stations in the surrounding districts has started. At the transfer stations to be installed collective garbage will be transported to sanitary landfills in the city center, which is a great challenge when considering the distances to the provincial centers of the maps shown in Figure 3.7

CHAPTER 4

MUNICIPALITY LAW AND SCOPE

In this section, the revised Metropolitan Municipality numbered 6360 law is discussed within the legal framework that was told above. Simply the difference between the old practice and new adjustment will be given.

The law in force before the publication of the new law is the law number 5216 published in 2004. As mentioned above for the management of MSW, the Metropolitan Municipality Law numbered 5216 (dated 23.7.2004) and the Municipality Law numbered 5393 (dated 13.7.2005) put the sole responsibility on the municipalities.

The metropolitan areas, which have a high transportation and communication network, are considered as a big market in the global economy, the center of the commercial center and the engine of the national economy (Zengin, 2014). Metropolitan cities are large cities and settlement areas consisting of many satellite towns surrounding them. In this sense, the metropolitan areas cover a large basin. This extensive basin appraisal will be an important assessment that shapes and renders the law. The authority and financial resources needed to solve urban problems in administrative structuring and operation were shared among multiple local government units. In the execution of services, there are incompatibilities between plans due to the fact that many units are authorized and the scale economics cannot be used. As a result, resources were being wasted.

The responsibility of the metropolitan municipalities basically included the collection, transportation, separation, recycling, disposal and storage of MSW. Regulations allow municipalities to assign other parties to carry out one or more of MSW management responsibilities (OECD, 2013). Central municipalities are responsible to collect waste from the household and transport to transfer station. Additionally metropolitan municipalities are responsible to landfill or dispose of the any kind of waste within the border of the city.

However, new regulations, which accepted within a bag bill, change the borders of metropolitan municipalities. Upon the justification for Law numbered 6360, one of the basic qualities of metropolitan cities is to have more than one settlement center and administrative unit within its borders. Local governments within the borders of the metropolitan area are required to handle these plans in a comprehensive framework that covers the entire metropolitan area, including macro-politics.

As a result of the scale economies arising from the single center implementation of the services provided in the metropolitan area, efficiency, coordination and quality in services can be increased and it will become possible to provide more and more quality services with fewer resources. Presenting services from more than one center to a larger and ideal center will also reduce the costs and per capita public spending.

By this revision municipalities are described as

> *"Metropolitan Municipality: Administratively and financially autonomous public legal entity of which decision making organs are elected by the voters and which comprises municipalities in the provincial territorial boundaries, establishes coordination between the municipalities: undertakes the duties and responsibilities conferred upon by the laws: and uses its powers whenever deemed necessary."*

> *"Cities have population greater than 750.000 can be transforming to Metropolitan Municipalities by Law"*

> *"Borders of Metropolitan Municipalities are Provincial territorial Boundaries. And Borders of District Municipalities are their territorial boundaries"*

The Law also implies all the villages within the border of Metropolitan municipality will be assumed as neighborhood (TBB, 2014)

By the law all the DM, far from the city center, go under the responsibility of metropolitan municipality. The Distance, infrastructure and capability of the DM's not take in consideration, while the law is renewed. This situation causes some gaps in administration system. The MSW management System of the DM's was not compatible with the disposition or land filling system.

CHAPTER 5

METHODOLOGY

In this chapter, the methodology followed throughout the study is described. In applying the methodology described; where necessary, several assumptions based on engineering judgment were made. The assumptions made, are clearly stated in the relevant texts.

5.1. Population Forecasting

To predict the solid waste generation in a community, it is necessary to predict the population of the community under consideration. In the literature, there are several different methods used for making population projections for communities. Population projection methods can be classified in three main groups according to, differences of acceptations, the using data and methods based on. These groups are namely, mathematical methods, economical methods and demography-based methods. Mathematical methods uses the existing data and easy to implicate (Kocaman, 2002). Each of the mathematical methods employs a variety of procedures and techniques to estimate the future population from the existing data of the population growth during the previous. The suitability of a method depends on the available data and also the preference.

In the present study, the population projection for the City of Ankara has been done for the year of 2036 considering a period of 20 years. It was aimed to create the most accurate and consistent projection by making population projections separately on the basis of total city and districts' population. Six different population forecasting methods for all district municipalities namely, *Exponential Growth Method, Least Squares Method, Compound Interest method, Arithmetic Increase Method,* and *İlbank Metho*d were used and compared. Population statistics of TURKSTAT, which are the statistical data of the past ten years, has been used as the data for projections. In this study, eight difference methods have been used for the whole city. Additionally, population projections by TURKSTAT, for Ankara up to 2023, have been extended to the year of 2036. And population projections up to 2036 for Turkey was proportioned to the population of Ankara. Finally, population growth rate of Ankara 2%, that calculated statistical data of TurkSTAT, is used for projection (TURKSTAT, 2016) .

5.1.1. Exponential Growth Method

Exponential growth refers to the situation where growth intensifies continuously – at every instant of time. Accordingly, it is sometimes called "instantaneous growth." In fact, geometric growth can be regarded as a special case of exponential growth, because population growth according to this model occurs at intervals much longer than an instant. The shorter the interval over which increments occur, the faster the population increases – just as the balance in a bank account with daily interest rate grows more quickly than one with yearly interest.

$$P = P_i \times e^{rt}$$

Where;

P_i = initial population

r = annual population growth rate

t = time

P = Projected population

5.1.2. Least Squares Method

This method is applicable when time-series data is available. It is a simple method commonly used to make future projections on the basis of the past trend. It is common to fit a straight line to the past observations.

$$y = a + bx$$

$a = \Sigma Y / N$

$b = \Sigma xy / x2$

y= observed population for years

x= number of observations

N= total number of observations

5.1.3. Compound Interest Method

This method assumes that the percentage of increase in population from decade to decade is constant. This method gives high results, as the percentage increase gradually drops when the growth of the cities reaches the saturation point. This method is useful for cities which have unlimited scope for expansion and where a constant rate of growth is anticipated. The formula of this estimation is :

$$P = P_f (1+r)^t$$

Where;

P_f = Last population

r = annual population growth rate

P = Projected population

t= year passed

5.1.4. Arithmetic Method

In this method, the rate of growth of population is assumed to be constant. This method gives too low an estimate, and can be adopted for forecasting populations of large cities which have achieved saturation conditions.

$$P = P_i + bt$$

Where

P = Projected population

P_i = initial population

n = time between P_i and P_f

t = time between P_i and P

b = Arithmetic population growth rate b = $(P_f - P_i) / n$

P_f = Last census

5.1.5. İlbank Method

This method is a method in which the increase is limited according to the method of geometric increase. The rate of increase is expressed by the multiplication coefficient (Ç)

$$Ç = \left(\sqrt[a]{\frac{N_y}{N_e}} - 1 \right) \times 100 \qquad \text{(Calculation of Ç value)}$$

$$Ç_{50} = 100 \times \left(\left(\frac{Ny}{Ne} \right)^{\frac{1}{a}} - 1 \right) \qquad \text{(Calculation of Ç value for 50 years)}$$

Where

Ç =Growth Coefficient

a = time interval (- year)

N_y =Last census

N_e =First Census

1≤Ç≤3

if Ç ≥ 3 ➔ Ç = 3

if Ç ≤ 1➔ Ç = 1

$$N_y = N_e{}^{*}\left(1+\frac{\bar{Ç}}{100}\right)^{n} \qquad \text{(calculation of population)}$$

Where;

N_y = Population

N_e = Last Census

Average Ç must be calculated after Ç calculated for all years.

5.2. Municipal Solid Waste Forecast

Forecasting of generation of MSW is vital in evaluating and in designing MSW management systems (Rimaityte, Ruzgas, Denafas, Racys, & Martuzevicius, 2012) and also in the analysis of economical dimension of MSW management systems. Forecast data serves as a basis not only for evaluating existing waste management system, but also suggesting a waste management system (Rimaityte et al., 2012).

The present study requires the amount of MSW of Ankara due to the research question needed to be forecasted. Forecasting the population for a specific area is a kind of matter of judgment (Hermann, 1964). Population forecasting has multiple methods in literature. However, the reliability of the forecast is closely related with the recorded data. No separated calculations done for rural areas, because the Metropolitan Municipality Law assumes all rural areas within the borders of Metropolitan Municipality, in other words; rural became urban. The direct projection method depends on previous recorded data. Previous statistical data of generated MSW in

Ankara is required for projecting the next 20-year's MSW generation. However, the required statistical data is not available not only for the Ankara Metropolitan Municipality but also for the DMs. The authorities of the municipalities declared, in face to face meetings, that there were no recorded data of MSW for the past decades. It was the result of uncontrolled landfilling. Additionally, a meeting done with the company officer of Invest Trading and Consulting (ITC) company, which is the contractor for disposal of MSW of Ankara. According to company officer the recyclable materials were being collected by scavengers before the collection truck of municipality arrives, thus real data about the generated waste cannot be recorded. Additionally, the company official declared that there were still uncontrolled and illegal dumplings' and they were out of record. On the other hand, the data about the amounts of MSW collected from villages before the MM Law do not exist. Because of all these lack of data, MSW forecasting is not by the calculation based on long term previous data. Traditional forecasting methods, for solid waste generation were frequently based on social and economic parameters, including the effects of population, income level, and the dwelling unit size in a linear regression model (Dyson & Chang, 2005). Total produced MSW is directly proportional to the population and income of population (Khatib, 2011). In this perspective, the population of Ankara City have been forecasted as a key parameter for MSW forecasting.

The officials of the ITC Company declared that there is no significant change in the quantity of waste collected from the City in the last five years. On the other hand, it is known that the population of the city is increasing. Thus, per capita solid waste generation must be decreasing to have almost constant SWG rate. Under the light of this information, daily solid waste generation per capita statistics of TURKSTAT have been analyzed.

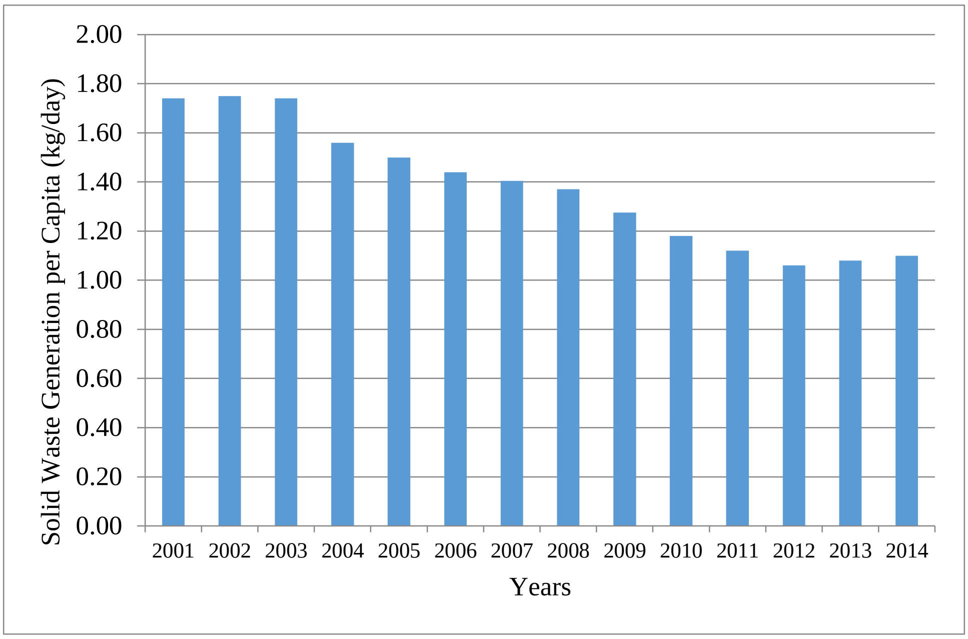

*Figure 5.1*Daily solid waste generation of Ankara (kg/day/person)

According to Figure 5.1, generation of solid waste per capita is in decreasing trend from 2001 to 2012, however there is a beginning of a little increase in 2013, which continued by 2014. There is no strong evidence why there happens a change in the trend. It is possible to say that the solid waste generation of PDs enters into Picture by 2014 after the law. This simple graphic is not enough to find out how solid waste generation of Ankara will move. To clarify the solid waste generation, another indicator is examined.

According to Shekdar (2009); Gross Domestic Product (GDP) affects the consumption behavior of the public in which directly related with the SWG per capita. The amount of solid waste generation per capita and GDP were compared in Figure 5.2 to see the validity of this situation for Ankara and to estimate a value for daily solid waste production per capita.

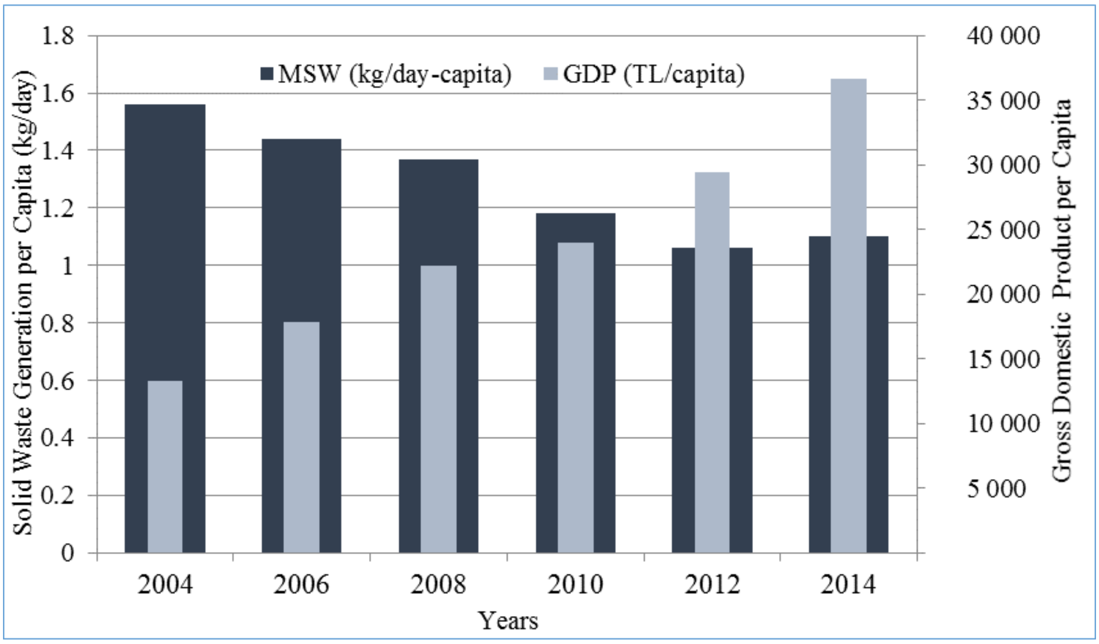

Figure 5.2: MSW generation and GDP of Ankara per capita (TURKSTAT 2014)

From Figure 5.2, it is possible to say that GDP of Ankara City is increasing however SWG is decreasing. Reason of this unconformity, which is not satisfying the general conditions in literature, can be based upon the miscalculation of GDP, missing statistical data or decreasing of purchasing power.

Finally, in Table *5.1* daily solid waste generation per capita is calculated for all districts separately, according to collected data from annual action reports. The solid waste generation of all the districts were around 1kg/day/person except Elmadağ.

Table 5.1 *MSW Generation of Districts. (kg/day/person) (data collected from annual action reports of DMs)*

Districts	Population	MSW (kg/day)	MSW (kg/day/person)
Akyurt	29,403	50,000	1.701
Altındağ	361,259	430,000	1.190
Ayaş	13,018	13,000	0.999
Bala	22,142	24,000	1.084
Beypazarı	47,646	44,300	0.930
Çamlıdere	6,781	8,000	1.180
Çankaya	913,715	1,271,000	1.391
Çubuk	84,636	140,400	1.659
Elmadağ	43,666	133,200	3.050
Etimesgut	501,351	430,000	0.858
Evren	2,901	3,000	1.034
Gölbaşı	118,346	124,000	1.048
Güdül	8,626	9,000	1.043
Haymana	31,176	43,000	1.379
Kalecik	13,604	23,000	1.691
Kazan	47,224	66,080	1.399
Keçiören	872,025	804,000	0.922
Mamak*	587,565	651,022	1.108
Kızılcahamam	25,767	27,000	1.048
Nallıhan	29,289	30,000	1.024
Polatlı	121,101	160,000	1.321
Pursaklar	129,152	130,000	1.007
Sincan	497,516	367,140	0.738
Şereflikoçhisar	33,946	35,000	1.031
Yenimahalle	608,217	878,340	1.444

ANKARA TOTAL	5,150,072	5,894,482	1.145
	Ankara average		1.251

*Information of Mamak district cannot be obtained from the municipality. Data taken as the average of central districts

As a result of all these comparisons and calculations, solid waste generation per capita of Ankara for next 20 year is assumed as 1kg/person in average for easy calculation, with respect to 20 years long projection of available data with decrease in SWG, increase in GDP and population. Additionally, variations of assumed value for SWG per capita (1kg/person) are ignorable with engineering judgment, while other variables and parameters are taken in the account.

5.3. Modelling

Ankara's waste storage system has been modeled for the economic analyzes to be carried out within the scope of the study. A system was planned to cover 25 district municipalities during modeling studies. Some assumptions had done to unify and simplify the calculations before generating scenarios. The model consisted of 5 main parts. These parts can be sorted as *collection, transportation, accumulation, transfer and storage*. The components used in the model were determined, after examining the methods used by the 25 districts municipalities, by choosing the most accessible, most efficient and simplest one. The scenarios in the study were formed by different combinations of the parts forming this model.

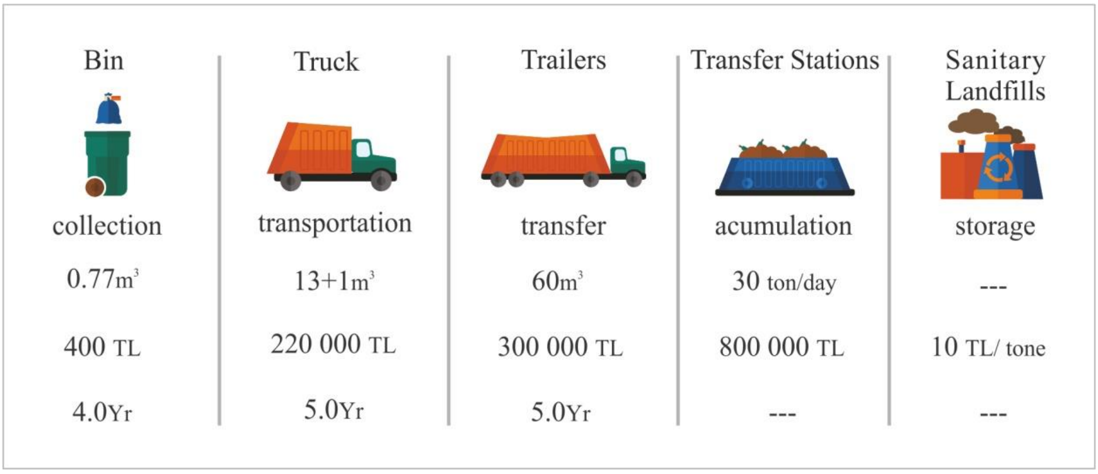

Figure 5.3 Parts of the developed model

5.3.1. Collection

Collecting is the process of gathering solid wastes that accumulate in the houses in the garbage bins on the streets. The main component of collection is garbage bins. The activity reports of the district municipalities were examined. Although there are differences between the municipalities, it is seen that the most common application was the galvanized garbage container and collection method was curbside. Households of Ankara were using market bags, which were different in size, thickness and quality, instead of manufactured bags to drop waste. Considering the characteristics of the trucks to be used in the transport system, the population density of the district municipalities and the efficiency of system, it was appropriate to use $0.77m^3$ of galvanized garbage containers in the model. In various studies, the containers were evaluated with a certain occupancy rate, but when considering the size of the model used and the amount of solid waste, a 100% occupancy rate was used to reduce the error margin and reduce the computational complexity. Cost of waste bins asked from the private sector's web page as 400.00 TL. The depreciation period for garbage containers by the Revenue Administration was set at 4 years. In this context, the containers used in the model will be renewed every four years.

5.3.2. Transportation

Transportation was defined as transporting the solid waste collected in the containers to the storage / disposal center by loading it on the appropriate transportation vehicle. The main component of transportation is garbage trucks. The district municipalities have been examined to determine the size and characteristics of the truck to be used in the transportation process. As well as the vehicle differences between municipalities, municipalities use different means of transport within their own. The physical conditions of the municipalities, the easy accessibility of the vehicle to be used and the facilities of operation are taken into consideration. Trucks with 13 + 1 m^3 of capacity with hydraulic clamping device and carrying capacity of 18 tons were selected as the garbage truck to be used in the model. The transportation component had two sub-components, which were forming its cost. These components were investment cost and operation cost. The operation cost of the trucks was depreciation and fuel costs. Fuel consumption was calculated based on working hours. The technical data of the trucks were taken from website of a truck producer as 4.5 L/hr. It was obtained from the municipal reports and similar works that the average time of a round for a truck, which begin at storage area, continue with driving in streets and end with dumping, was 2 hours. In this context, a truck was running 4 times a day. The total number of trucks was calculated according to these variables. The price of the truck was selected as 220,000 TL with respect to market prices. The depreciation period for trucks according to the Department of Revenue Administration was five years. Depreciation calculations were made over this period and trucks were to be renewed at the end of 5 years. According to Department of Revenue Administration depreciation constant of a truck for an hour calculated as 0.000171.

Depreciation Cost *(TL/month)* = Constant x Price of vehicle *(TL)*x Daily working Hour *(hr/day)* x Monthly working day *(day/month)*

There were also workers needed to operate the trucks. Garbage trucks were operated with a total of 3 personnel, one driver and two collectors. The costs incurred by the workers were the working fees, the road and meal allowances. The gross minimum wage(GMW) of 1647 TL, determined by the Ministry of Labor and Social Security for the year 2016, was taken as the working fee. The expenses of a worker were calculated by the Public Procurement Authority wage calculation schedules. Daily meal and transport fees of workers have taken from private sector; prices were 13.70 TL and 5.00 TL respectively. The working duration was 8 hours a day over 26 days per month.

Worker Unit Cost= (GMW+ Monthly Working Day *(day/month)*x (Gross Meal Fee *(TL)*-3.29 *TL* + Gross Transport Fee*(TL)*) x (1+ Employer%))+ 85.54 *TL(Meal exception amount)*

5.3.3. Transfer Stations (TS)

Transfer stations are used for temporary storage of MSW in order to transfer the waste transported by trucks to bigger vehicles before being taken to the final disposal site. The principal reason for using transfer stations is economics. Currently, there are no transfer stations used in Ankara City. Transfer stations were proposed to be used in the scenarios created in the study. The daily solid waste quantities of the district municipalities have been taken into account to characterize the transfer station to be modeled. It was deemed appropriate to use solid waste transfer stations with a capacity of 30 tons per day in the model. The number of transfer stations to be established in the relevant locations was found to be proportional to the population of that district. The costs of transfer stations were categorized in two sub-groups as installation and operation. Installation prices were asked from the private sector. As the transfer station installation fee quotation for the 30 tons capacity station, 800,000.00 TL was taken from private company that is EMS Makina İnşaat ve Dış Tic. Ltd. Şti. and used for the model. Similar works in the literature for operating costs have been examined in terms of garbage volumes and operating conditions. The model was based on the operating cost of the Istanbul example (Güllü, 2006), which is the most appropriate example for the special conditions of Ankara. According to study, operation cost of TS in Istanbul was calculated as 6.5 TL/ton with respect to 2004 prices. For Ankara, the operating cost was updated by using US dollar exchange rate during study, after the update; the cost was reached 14.00 TL/ton. (1$=1.506 TL-2004 , 1$=3.25TL-2016)

5.3.4. Transfer

The transfer operation was defined as the transfer of the solid waste accumulated at the transfer stations to the final disposal center with the appropriate vehicles. The characteristics of the vehicle to be used for the transfer were selected taking into account the amount of solid waste to be transported. Special production trailers of 60 m^3 capacity were used in the model. The main costs of the transfer process defined as operating and investment costs. Market research done and the price quotation of 300,000 TL was taken from private company that is EMS Makina İnşaat ve Dış Tic. Ltd. Şti. and used in the model. Calculation of operating costs from fuel, workers, and maintenance-repair items is not considered appropriate in terms of the reliability of the calculations and the scope of the work. In this context, the studies in the literature examined and average transfer cost for Istanbul, which was calculated as 0.36 TL/ton-km by Yaman (2012), according to information's of five different transfer stations cost updated to be 0.62 TL/ton-km. The total length of roads to be transferred for the calculations made in the model was taken as the total distances of the district centers to the provincial center.

5.3.5. Disposal

In this study, two different landfill types were used for modelling. These were namely uncontrolled landfills and sanitary landfills. Uncontrolled landfills assumed as cost free. Setup cost and operational cost of uncontrolled landfills are ignorable. On the other hand, setup cost and operational cost for sanitary landfills are parameters depended on the scale of landfill.

5.3.6. Uncontrolled Landfills

Uncontrolled MSW landfills or dump sites are the simplest but illegal MSW disposal methods that involve without any pretreatment or infrastructure installation. In other words, it involves direct disposal of MSW to dump site. The only application for this system is systematic covering of disposed MSW with soil. This application has negligible cost with respect to amounts of solid waste disposed.

5.3.7. Sanitary Landfills

The disposal was defined as the destruction of the solid waste by the appropriate method in the most reduced amount of environmental damage. There were many disposal options among solid waste management systems. The calculation and modeling for each disposal option were likely to exceed the scope of this thesis. The sanitary landfill system was taken as a disposal system. The regular storage system involves the storage of the wastes after the preparation of suitable floor and drainage systems and the covering of the wastes with the appropriate thick soil. The installation and operation of the system generated separate costs. In long-term systems, the storage area was built in parts over time, but the planned storage areas in the scenarios were relatively small. It was thought that the whole of the landfills can be constructed at first because the planning was also short-term. In this study, unit setup cost of a SLF was searched from literature and five different costs were founded. Costs were belonging to Oklohoma, İstanbul, Kahramanmaraş cities. The setup costs of the facilities compared due to the modeled capacity, calculation methods and timeliness. The most suitable cost, according to aim of this study, was calculated as 10 TL/ton. Unit operation cost for SLF's was taken from the literature as $10 which was equal to 30.93 TL/ton from the calculated values for İstanbul by Gültekin Güllü. (2009)

5.4. Description of Scenarios

The population of Ankara is bigger than most European countries and many European cities. In this context, the scenarios established for Ankara were not much utilized in evaluations and reviews in the literature. It is very difficult to make comparisons or similarities when considering the size of the area as well as the size of the population. Four different scenarios were developed according to special local conditions of Ankara City, which were summarized in previous sections. Each scenario was economically evaluated with the contemporary prices of the goods and services, the use in the MSW management system. MSW management system of the city was two parted, central part and peripheral part. Before the new law, the CDMs were taken their collected waste to SLF's in Mamak and Sincan and the PDMs were delivering their collected MSW to their uncontrolled landfills. According to new law, the MSW management system of peripheral municipalities was linked to the metropolitan municipality, thus scenarios, were depended on MSW management system of PDMs.

5.4.1. Scenario – 1: MSW Management System before the New Law

In this scenario, the previous MSW management system was evaluated. The collection and transportation parts of the model created in this scenario were used. The MSW management system of the city was processing in two different ways with respect to CD and PD before new Metropolitan Municipality Law. Central Municipalities were delivering their collected waste to sanitary landfills, which are located in Sincan and Mamak; the Peripheral Municipalities were delivering their collected MSW to their uncontrolled landfills (Figure 5.4). That system was in use before the year 2014.

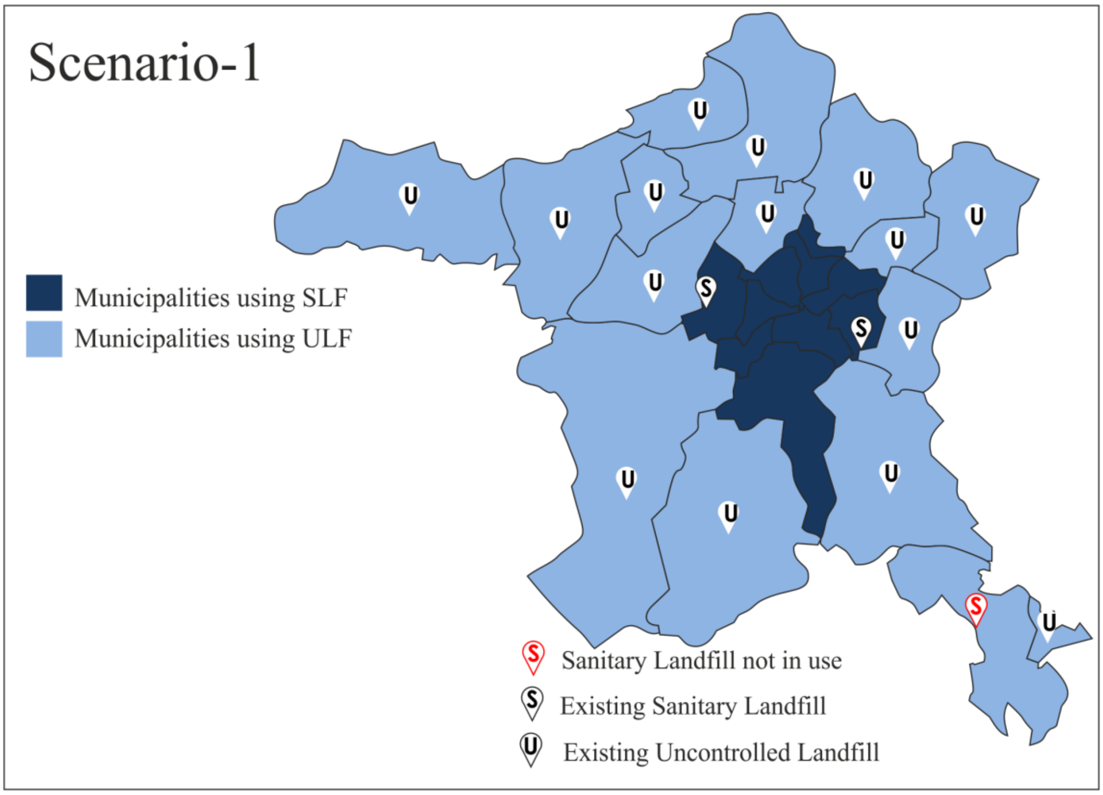

Figure 5.4 Schematic representation of Scenario-1.

In Scenario-1, if the new law was not published, the answer to the question of what will be the burden that the current situation will bring to the budget is sought. Cost comparison with other proposed scenarios was provided.

In Figure 5.5, utilized components for CDMs and PDMs were showed separately. According to the scenario, solid waste was dropped to waste bins by households, this waste was taken from bins to landfills by trucks and workers, for the final disposal. All the components were available in the fixtures of district municipalities. In other words, there was no need to additional purchase.

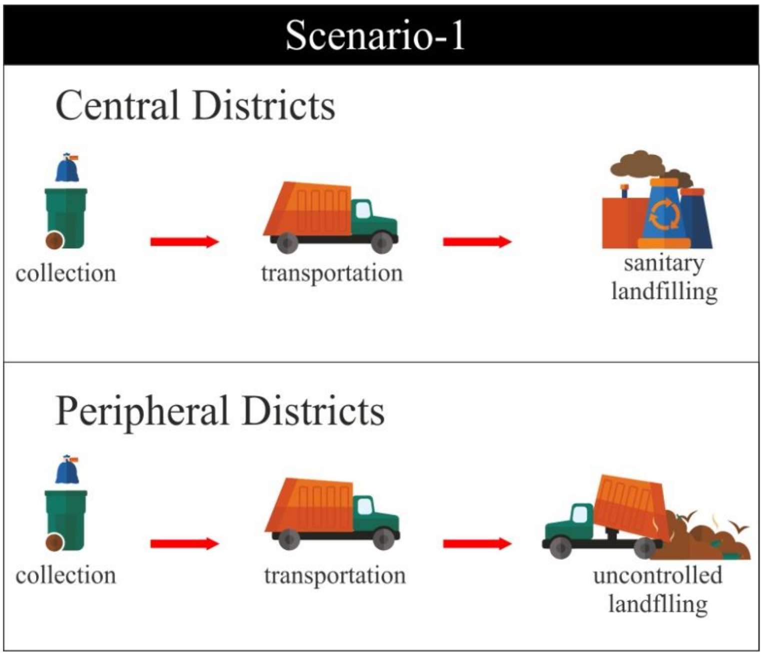

Figure 5.5 Flow diagram of Scenario-1

5.4.2. Scenario – 2: Current System

In Scenario 2, a review of the MSW management system established in Ankara after the publication of the new law was carried out. This system involved the transfer of collected solid wastes to the sanitary landfills in Mamak and Sincan through the transfer stations that will be built on the wild storage areas located in the districts. In this scenario, all phases of the model created were used. Solid wastes collected in containers were transported to transfer stations via waste trucks and solid wastes collected at transfer stations were transferred to regular landfill sites in the province center through trailers (Figure 5.6)

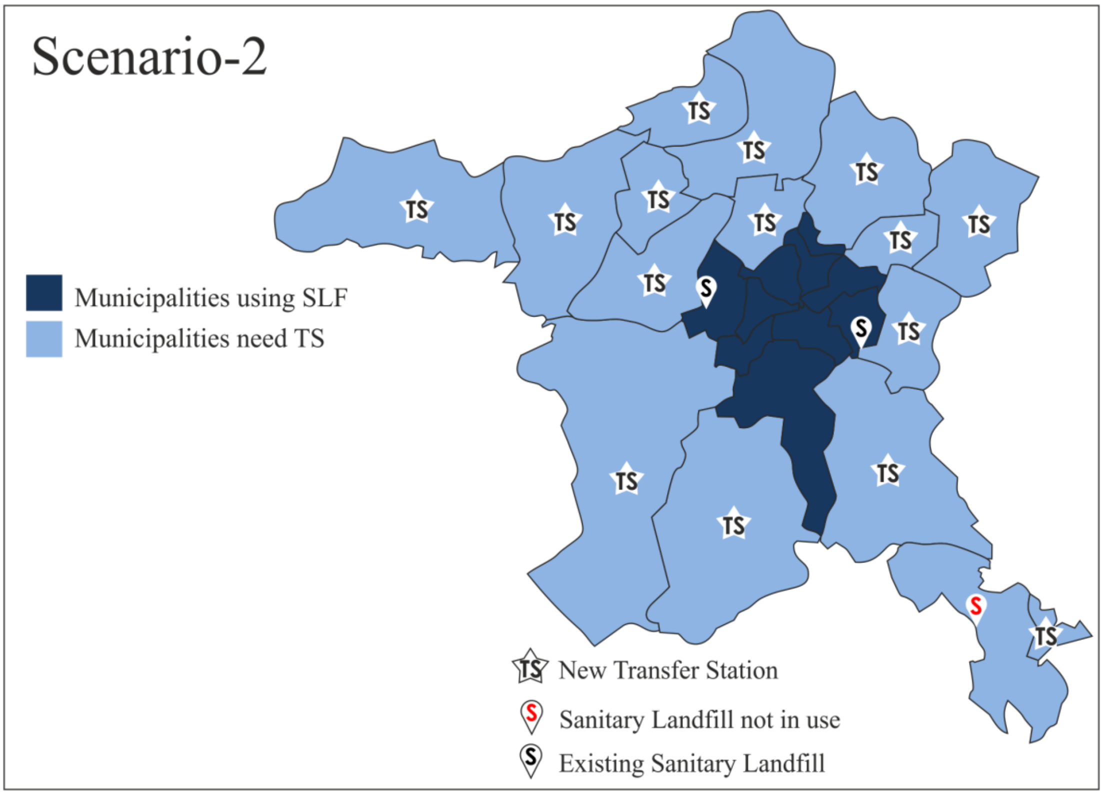

Figure 5.6 Schematic representation of Scenario-2

In this scenario, the transfer distance from transfer stations to sanitary landfills as calculated as a sum of all the direct distance from center of PDMs to CDMs.

According to scenario, CDMs and PDMs have different components. MSW flow of the CDMs was same with Scenario-1, however MSW flow was different in the PDMs as seen Figure 5.7.

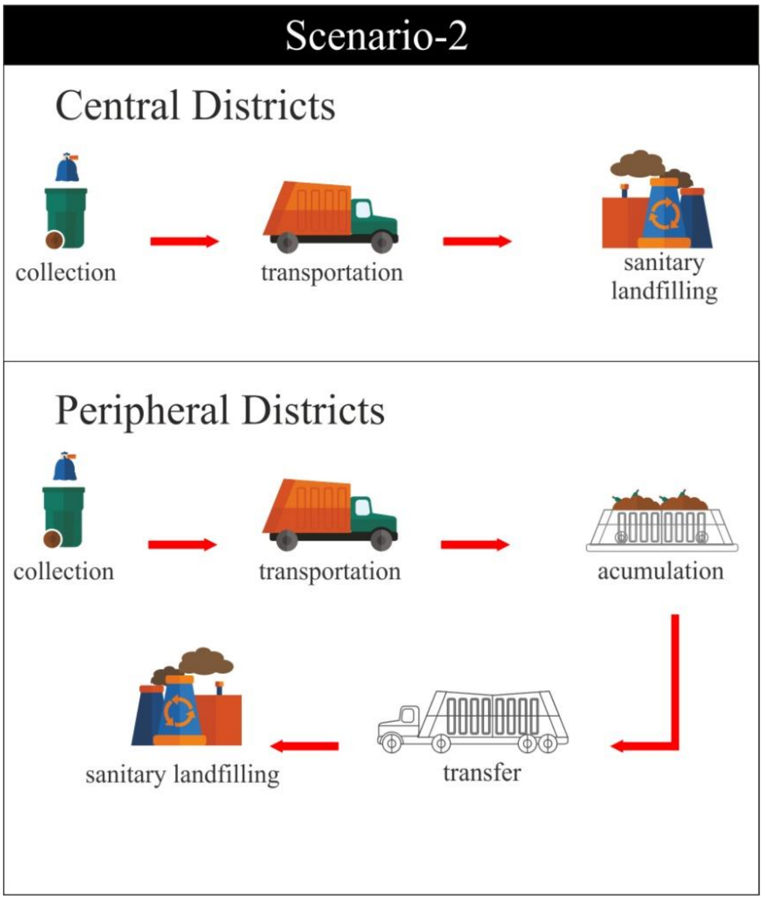

Figure 5.7 Flow diagram of Scenario-2 (Outlined components needed to be purchased)

In this scenario, solid wastes were dropped to waste bins by households and taken by trucks to the transfer stations. Accumulated MSW is transferred to the sanitary landfills by trailers. According to this flow, PDMs are needed to purchase transfer stations for accumulation and trailers for transfer of MSW.

5.4.3. Scenario – 3: Sanitary Landfill to each Peripheral District

Scenario-3 was created with the idea that every PDM of Ankara would solve the solid waste problem within their own boundaries. At this point, sanitary landfills were planned to be established in each district. This scenario was one of the alternatives of the solid waste management system that can be used within the borders of Metropolitan Municipality of Ankara after the new law. In this scenario, the three components of the developed model were used. Solid wastes collected in containers were considered to be transported directly to landfills via garbage trucks (Figure 5.9).

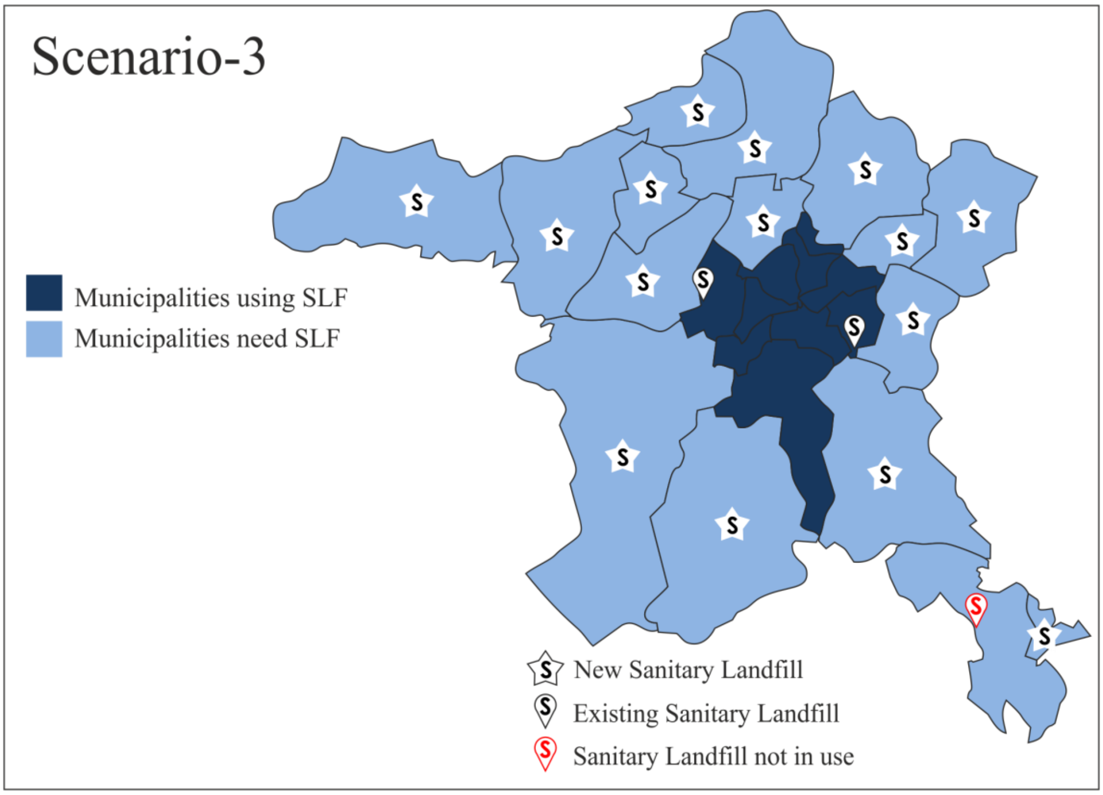

Figure 5.8 Schematic representation of Scenario-3

The best point of the scenario-3 is that there is no need to purchase new trucks and employ new workers for long distance transfer and no need to installation of transfer stations. The system simply uses the existing infrastructure with an addition that all districts will own their sanitary landfills as shown in Figure 5.8.

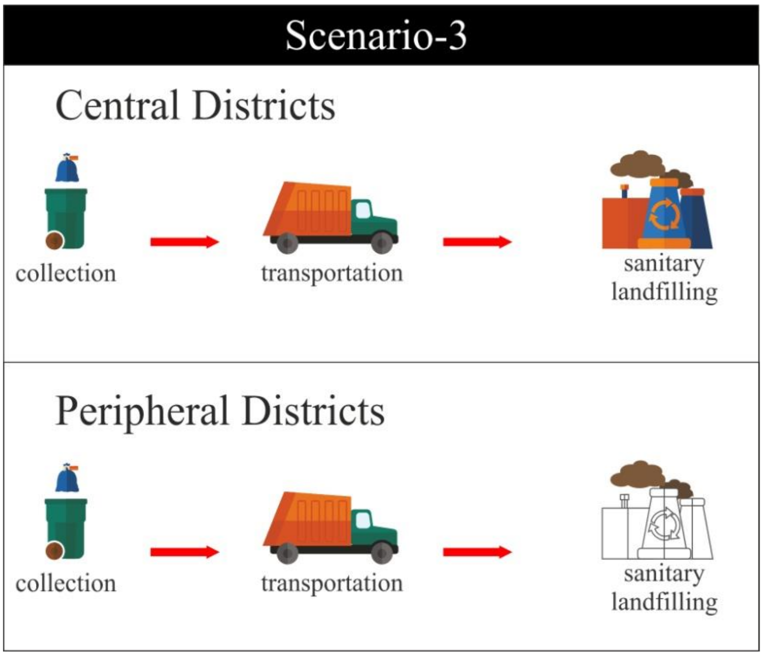

Figure 5.9 Flow diagram of Scenario-3 (Outlined components needed to be establish)

5.4.4. Scenario – 4: Sanitary Landfill to each Peripheral District groups.

Scenario-4 was the simplified and modified version of Scenario -3. This scenario was developed according to marginal cost concept of economic sciences. According to a study, that conducted in İstanbul, average cost for MSW management is minimized for PDMs, where the collected waste was approximately 200,000 kg/day (Kaya, 2013). In other words, this amount equals the production of solid waste in a settlement with a population of 200,000 according to the assumptions of this study. In this scenario, PDs of Ankara were grouped according to their population and transportation opportunities. Total population of grouped PMs was approximated to optimum population as much as possible. The transportation distance was tried to be remain around 45 km maximum between the centers of PDMs and sanitary landfills, except Bala Municipality. Bala Municipality was 100 km away from the Mamak sanitary landfill and 80 km away from the Sereflikoçhisar sanitary landfill site, which is not in use. For this reason, considering the length of the distance to the sanitary landfills, it was planned to establish a transfer station in the Bala district. Additionally, Elmadag and Ayaş municipalities were close enough to transport their solid wastes to existing sanitary landfills in Mamak and Sincan-Çadırtepe respectively. For this reason, Ayaş and Elmadağ districts in this scenario used existing SLF and the calculations within the scenario were made accordingly. Grouped municipalities with the approximate location of planed facilities can be seen in Figure 5.10.

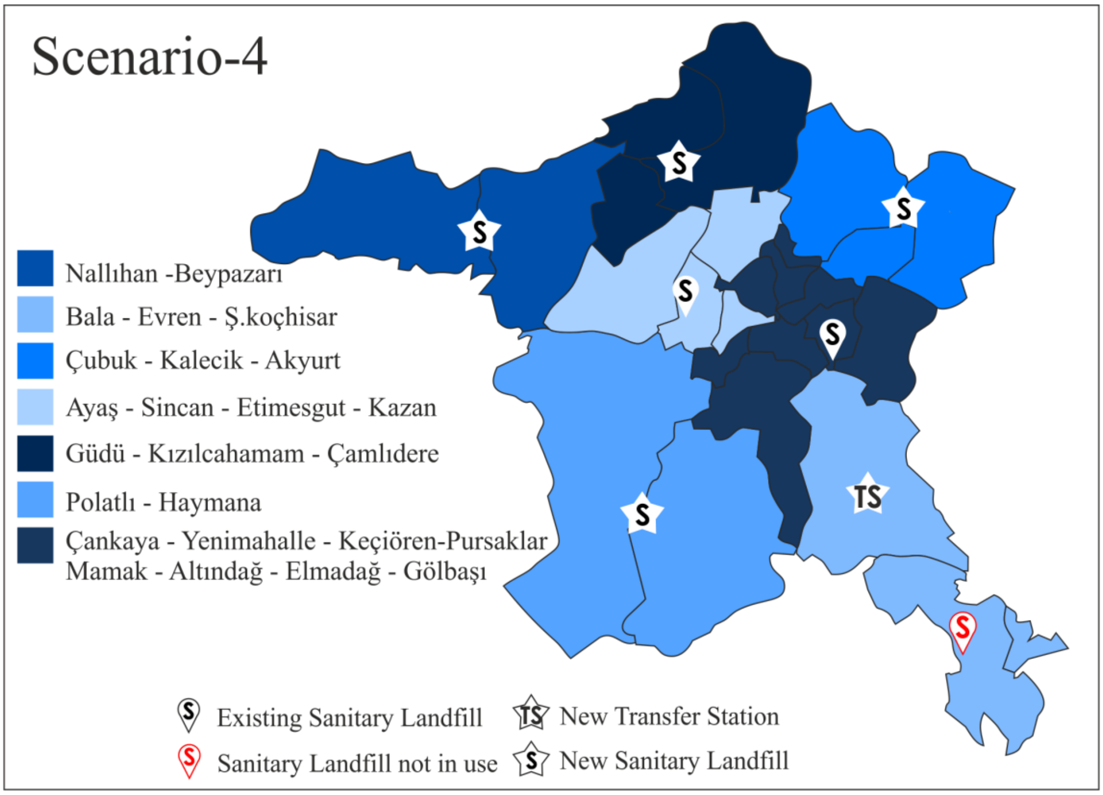

Figure 5.10 Schematic representation of Scenario-4

In this scenario, the components of the created model were used in different combinations. For Ayaş and Elmadağ districts, collection and transportation components were used. Collection, transport, storage, transfer and disposal components were used for the Bala district. Finally; collection, transportation and disposal components were used for the other PDs.

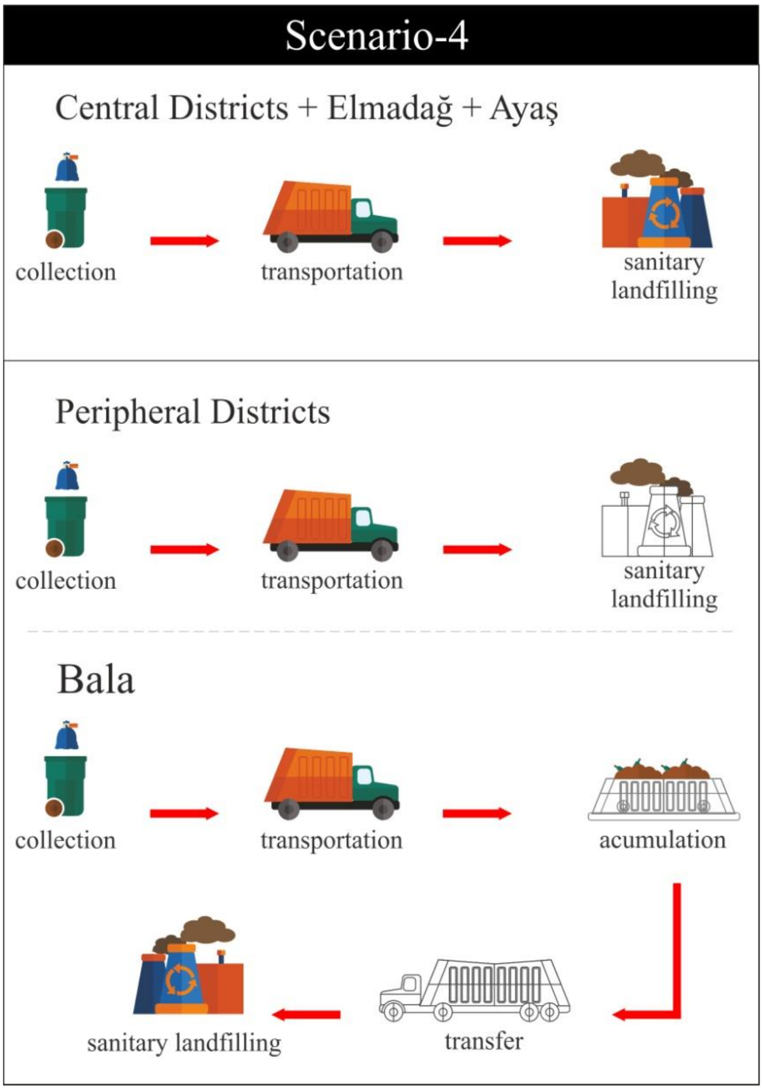

Figure 5.11 Flow diagram of Scenario-4 (Outlined components needed to be established or purchased)

5.5. Economical Evaluation

MSW management system is a multi-parameter system that has many alternative solutions and possibilities, thus it was simplified to main variables of the system. These variables can be classified as, collection, transportation, accumulation, transportation and disposal system.

All the systems except solid waste generation were closely related with the amount of MSW that generated in the city in a day. Amount of MSW generated in a city was directly related with population of the city.

In the framework of the created model, economic analyzes were made by using separate combinations for each scenario. The quantities of fixtures and the sizes of the structures needed during the economic analysis were associated with the daily or annual solid waste generation amounts of the district municipalities. In this point, the amount of solid waste calculated in kilograms was used by converting to cubic meters or tons according to the properties of the component. In the calculations made, the calculated decimal quantities of fixtures and workers were rounded up to the nearest whole number.

Economic analysis was carried out in two main sections. The first one was the cost analysis for the CDMs and the other one was for the PDMs. The PDMs had been subjected to 4 different cost calculations based on four different scenarios. Since no change in the status of the central districts after the Law numbered 6360 was made, the cost calculations results for the CDMs were added to the economic analysis results made for the PDMS under the scenarios considered.

In the scope of the study, a separate model for the central districts had not been established and economic evaluation of existing systems had been tried. The components used in the model were used in the cost analysis of for the CDMs in order to ensure integrity in the study. The central districts' solid waste management system components were collection, transportation and disposal.

As indicated, the economic analysis for the PDMs was carried out within the framework of the scenarios created. In the calculations made for Scenario-2, Scenario-3 and Scenario-4, the number of fixtures and facilities needed or considered during the cost estimations was not proportional to the amount of solid waste produced. The mentioned components were determined as needed so that there was at least one in each PDM. In addition, it was predicted that the unit investment costs of the landfills planned to be made under Scenario-4 in the context of marginal cost concept would decrease. For this reason, the unit cost, which was accepted as 10 TL/ton in the calculations, has been reduced by 10% and 15%, and the possible costs have been calculated. Diesel fuel prices for November 2014 (4.15 TL / L) were used during the economic analyzes.

Four core values were calculated for the management of MSW from the CDMs under four scenarios. These values were initial investment cost, total investment cost, total operating cost and total cost, respectively. All calculated values other than the initial investment cost were converted to net present value. Average annual inflation data for the last 12 years published by TURKSTAT had been taken for net present value calculations (Table 5.2). In this context, 8% was used as the inflation rate.

Net Present Value (NPV)

Net Present Value (NPV) is a formula used to determine the present value of an investment by the discounted sum of all cash flows received from the project. The formula for the discounted sum of all cash flows can be rewritten as

$$NPV = \sum_{t=0}^{n} \frac{Rt}{(1+i)^t}$$

Where;

R_t = net cash inflow-outflows during a single period t

i = discount rate or return that could be earned in alternative investments

t = number of time periods

Table 5.2 *Consumer price index numbers (TURKSTAT 2017)*

Years	Average of Annual rate of change (%)
2004	8.60
2005	8.19
2006	9.59
2007	8.78
2008	10.43
2009	6.28
2010	8.58
2011	6.45
2012	8.94
2013	7.49
2014	8.85
2015	7.67
2016	7.79
Average	8.28

All assumptions regarding calculations made during economic analysis were given in Table 5.3.

Table 5.3 *Assumptions for cost calculations*

Assumptions	Value	Unit
Unit waste generation	1.00	kg/day-person
Unit weight of uncompressed waste	0.40	ton/m^3
Capacity of a container	0.77	m^3
Cost of a container	400.00	TL
Amortization period of a container	4.00	years
Capacity of a truck	18.00	tones
Capacity of a truck	13.00	m^3
Cost of a truck	220,000.00	TL
Amortization period of a truck	5.00	years
Duration of a round	2 - 3	hour
Fuel consumption of a truck	4,50	lt/hr
Fuel unit cost	4.15	TL/lt
Daily working hour	8.00	hour
Monthly working day	26.00	day
Capacity of a trailer	60.00	m^3
Cost of a trailer	300,000.00	TL
Operation cost of a trailer	0,62	TL/ton-km
Setup cost of a transfer station	800,000.00	TL

Assumptions	Value	Unit
Operation cost of transfer station	6.00	TL/ton
Setup cost of a sanitary landfill	10.00	TL/ton
Operation cost of sanitary landfill	30.92	TL/ton
Total distances of PDMs to sanitary landfill	1,076.00	km

CHAPTER 6

RESULTS AND DISCUSSION

In this study, population projections of Ankara by the year 2036 were done. Four different scenarios were developed for the solid waste management systems of the cities due to the projection made within the responsibility of Ankara metropolitan municipality. These scenarios were compared in terms of initial investment cost, total investment cost, total operating and maintenance costs and total cost.

All expenditures incurred by the proposed systems for 20 years were calculated as initial investment cost, total investment cost, total operating and maintenance costs and total cost. During the total cost calculations, inflation-based price increases were not considered. This is to see the financial burden that the population increase will bring to metropolitan municipality for 20 years naked. There were too many financial values used in the calculations and these values showed an unpredictable variability due to the conditions of country. This variability was not considered in calculations because it was making it difficult to have a healthy analysis. This way the analysis becomes more understandable.

In the following section, the population projection results for Ankara City, the number of fixtures and the system variables are given. Than economic analysis results of the enhanced scenarios are given on three basis such as Capital Expenditure (CapEx) and operational expenditure (OpEx) and total cost. The calculated values were converted to net present value to compare effectively by using an annual discount rate of 8%. Comparisons between scenarios were made over these values.

6.1. Population Projections

The total population of Ankara was calculated for the next 20 years by nine different methods using TURKSTAT data for the last 15 years (2000 - 2014). Projection data for the total population of Ankara were given in the Table 6.1

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All the results calculated for 20 years were significant depending on the calculation method they belong to. Population projections were made district – based manner to confirm the constructed population projection and to select the projection method to be used in the study. The results of the projections made for the districts were examined separately on a district basis. It has been observed that the population of Çamlıdere and Evren, the districts which have a tendency to decrease their population for the last 8 years, has fallen to minus values in 2036 when they were calculated with least squares and arithmetic method.

Table 6.1 *Summary table of Ankara's population projection*

Years	Exponential Method	Least Squares Method	Compound Interest Method	Arithmetic Method	TURKSTAT (Projection of Ankara 2023 extended)	TURKSTAT TÜRKİYE Projection reduced	Population Growth (0,02) (Last decade)	Iller Bank Avg-Ç	Iller Bank 50 -Ç
2016	5,392,352	5,898,222	5,390,967	5,343,100	5,324,705	5,325,464	5,380,767	5,390,967	5,394,802
2021	6,044,768	7,009,909	6,035,455	5,705,728	5,758,868	5,585,150	5,967,260	6,035,455	6,061,264
2026	6,776,118	8,121,596	6,756,991	6,068,355	6,171,588	5,812,198	6,617,681	6,756,991	6,810,058
2031	7,595,954	9,233,283	7,564,786	6,430,982	6,550,983	5,997,441	7,338,996	7,564,786	7,651,357
2036	8,514,981	10,344,970	8,469,153	6,793,610	6,887,162	6,140,459	8,138,932	8,469,153	8,596,588

Taking this into consideration, the results of the least squares method and the arithmetic method have been excluded. Within the results of the provinces, it was observed that the population of Evren district would be below 2000 persons in all projections. In this case, the status of the district would be converted to village according to Village Law numbered 442.

This study is mostly depended on peripheral Municipalities, and evaluation of scenarios is needed to be done on district municipalities level. To have an accurate population forecast, population projections of sub municipalities of Ankara have been done by using the statistical data of the last nine year (2007-2015). For this projection, six different projection methods have been used. These six methods have different results each (Table 6.2).

Table 6.2 The total population of district municipalities by different methods

Years	Exponential Method	Least Squares Method	Compound Interest Method	Arithmetic Method	Iller Bank$Ç_{Avg}$	Iller Bank 50-Ç
2016	5,393,433	5,826,776	5,390,103	5,363,028	5,264,504	5,260,107
2021	6,123,706	6,305,466	6,095,115	5,825,291	5,950,403	5,919,679
2026	7,109,615	6,784,156	7,033,435	6,287,555	6,888,957	6,819,484
2031	8,471,102	7,262,845	8,307,933	6,749,819	8,202,841	8,070,448
2036	10,391,854	7,741,535	10,072,938	7,212,083	10,082,443	9,841,315

The projections made for the villages and districts of Ankara have been examined comparatively. Out of the least squares method and the methods other than the arithmetic method, the results of Iller Bank's 50-Ç method showed meaningful and approximate results for both projections. This method was also the most common method used for population projection by public institutions in Turkey. Projection results of the 50-Ç method of Iller Bank were used in the calculations made in the continuation of the thesis study.

After the projection with Iller Bank’s 50-Ç method, the population of Ankara's districts was examined comparatively on the map. Population data for the years 2016 and 2036 were mapped on city maps.

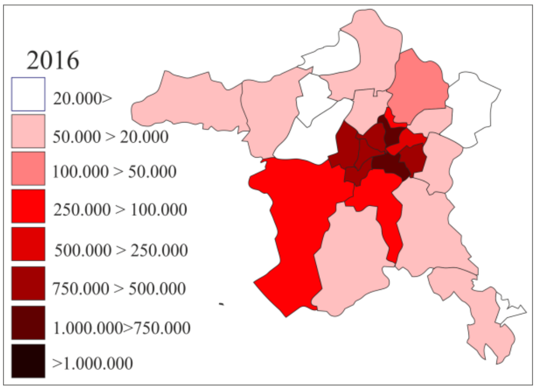

Figure 6.1 Population distribution of Ankara in 2016

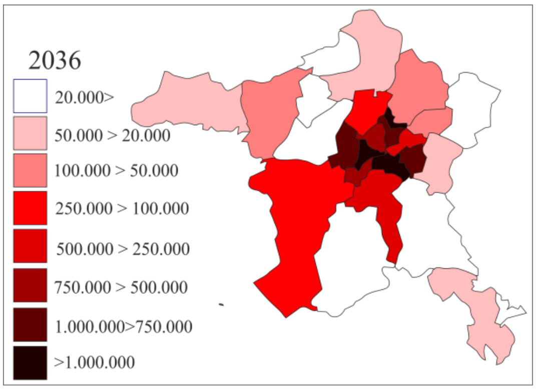

Figure 6.2 Population distribution of Ankara in 2036

It was observed that the population has increased and concentrated in the city center for the next twenty years. In general, the population in the PDs has decreased. The districts that were accepted as the central district, before the Law for Metropolitan Municipality, host 90% of the total population of the city in 2016. According to the projection, the population of the CDM would rise from 4,699,073 to 9,234,400 over 20 years, and would account for about 94% of the total city population.

6.2. Fixture Calculations

Daily solid waste production quantities of the districts were calculated according to the data of the created population projection. Depending on the calculated solid waste amount, the fixtures to be acquired within the solid waste management system were planned for twenty years (Table *6.3*).

Table 6.3 *Inventory table calculated according to years for central districts*

Central Municipalities	*Population = Generated SW*	*Container Needed to be purchased*	*Truck Needed to be purchased*	*Total Person Needed to be Employed*
Unit Years	*kg/day*	*0.77 m^3*	*13 m^3*	*3 person/truck*
2016	4,699,073	15,260	226	678
2017	4,815,406	377	6	696
2018	4,938,631	399	6	714
2019	5,069,276	426	6	732
2020	5,207,915	15,708	7	753
2021	5,355,168	857	233	774
2022	5,511,712	906	13	795
2023	5,678,278	968	15	822
2024	5,855,665	16,282	14	846
2025	6,044,737	1,471	16	873
2026	6,246,436	1,562	243	903
2027	6,461,785	1,666	23	933
2028	6,691,895	17,029	26	966
2029	6,937,978	2,269	26	1002
2030	7,201,349	2,420	29	1041
2031	7,483,442	2,581	256	1080
2032	7,785,814	18,010	38	1125
2033	8,110,164	3,324	41	1170
2034	8,458,340	3,550	43	1221

Central Municipalities	*Population = Generated SW*	*Container Needed to be purchased*	*Truck Needed to be purchased*	*Total Person Needed to be Employed*
2035	8,832,354	3,795	47	1275
2036	9,234,400	19,315	275	1332

In all calculations, the number of fixtures was found to be proportional to the amount of solid waste. The amount of solid waste calculated by weight was multiplied by a constant of 0.4 ton/m^3 to convert the volume. The value was found to be proportional to the capacities of the container and garbage trucks and the amount of fixtures needed. Considering that garbage trucks can do many times of service during the day, the number of trucks needed was determined. It was foreseen to make renovation / replacement at the end of the amortization period of the vehicles and gears used for 20 years. In this way, it was calculated that the tool and gear used would be renewed at regular intervals.

Table 6.4 *Inventory table calculated according to years for PDs*

Peripheral Municipalities	Population = Generated SW	Scenario- 1 – 2 –3			Scenario – 2	
		Container Needed to be purchased	Truck Needed to be purchased	#Total Person Needed to be Employed	Trailer Needed to be purchased	Transfer Station needed
Units Years	kg/day	0.77 m^3	13 m^3	3 person /truck	60 m^3	30 ton /day
2016	561,034	1,825	28	84	19	19
2017	561,336	0	0	84	0	0
2018	561,834	0	0	84	0	0
2019	562,527	3	0	84	0	0

2020	563,419	1,829	0	84	0	0
2021	564,511	3	28	84	19	0
2022	565,804	3	0	84	0	0
2023	567,302	10	0	84	0	0
2024	569,006	1,835	0	84	0	0
2025	570,921	6	0	84	1	1
2026	573,048	13	28	84	19	0
2027	575,392	17	0	84	0	0
2028	577,955	1,841	0	84	0	0
2029	580,743	16	0	84	0	0
2030	583,758	23	1	87	1	0
2031	587,006	30	28	87	19	0
2032	590,492	1,850	0	87	0	0
2033	594,220	29	0	87	0	0
2034	598,196	36	0	87	0	0
2035	602,426	43	1	87	2	1
2036	606,915	1,863	29	90	19	0

6.3. Cost Calculations for the Scenarios

The results of calculations for the central districts and the four selected scenarios are discussed comparatively in the following section.

The prices of the fixtures and the costs of the facilities to be built, which were required for the planned solid waste management system, were included during the calculations of the investment costs. Personnel expenses, fuel costs and other expenses were included in operating costs and not included in investment calculations.

6.3.1. Central Municipalities

Solid waste management systems did not need to be rearranged as there was no change in the situation of central provinces after the Law numbered 6360. The Central districts were also analyzed in the framework of the model in order to evaluate and compare the whole solid waste system within the scope of the study. The results of the analysis were detailed below under the headings of investment costs, operating costs and total cost.

6.3.1.1. CapEx (Capital Expenditure)

The initial investment costs include the investment costs that may be required in the case that the solid waste system of 8 villages which are considered as central districts in this study is installed from scratch. Calculated values were converted to net present value and are given in Table 6.5. 90% of the investment to be made for the amount of solid waste produced in the first year was the establishment of the SLFs. The remaining 10 percent of the cost was shared among the collection costs in a 1 to 9 ratio.

There was no investment cost associated with the accumulation and transfer operations because the districts were relatively close to the disposal centers. The total initial investment cost calculated may be distributed to the district municipalities in proportion to the district population.

Table 6.5 *NPV of initial investment cost for the CDMs*

Initial Investment	**554,486,350.00**
Total Collected Waste	**1,715,161.65**
A- Collection (B+C)	55,824,000.00
B- Waste Bin	6,104,000.00
C- Trucks	49,720,000.00
D-Transfer Stations	0.00
E-Trailers	0.00
F-Uncontrolled LF	0.00
G-Sanitary LF	498,662,350.00

Investment Unit Cost (TL/ton)	**323.29**

Table 6.6 *NPV of total investment cost for the CDMs*

Total Investment	693,541,110.16
Total Collected Waste	**49,866,234.12**
A- Collection (B+C)	194,878,760.16
B- Waste Bin	24,730,439.93
C- Trucks	170,148,320.24
D-Transfer Stations	0.00
E-Trailers	0.00
F-Uncontrolled LF	0.00
G-Sanitary LF	498,662,350.00
Investment Unit Cost (TL/ton)	**13.91**

The possible purchases and investments of central provinces for the next 20 years were calculated as a result of the projections made. The total amount of the calculations was converted to the net present value and given in Table 6.6. Approximately 72 percent of the total investment costs were generated by SLF installation costs, while the remaining 28 percent were belonging to the collection operation. When the total investment costs were converted into unit prices, the investment cost per ton was calculated as TL13.91. At this point, when considered in the framework of the scale economy, the unit cost can be regarded as an average value for the cities with similar population size and population increase rate in Turkey.

6.3.1.2. OpEx (Operational Expenditure)

The operating cost of the solid waste management system for the central districts for 20 years was calculated. The present values of the converted costs were presented in Table 6.7. As seen in the table, about 99 percent of the operating and maintenance costs were belong to collecting operations. Labor costs have constituted 57 percent of the total operating cost of the collection operation. This cost was followed by costs of garbage trucks by 42 percent. When considered at the unit cost point, the operating cost for 1 ton of solid waste was calculated as 10.17 TL.

Table 6.7 *NPV of operation and maintenance cost for the CDMs*

Total Operation and Maintenance	**506,915,217.57**
Total Collected Waste	**49,866,234.12**
A- Collection (B+C)	505,064,167.90
B-Trucks	216,609,142.57
C-Worker	288,455,025.33
D-Transfer Stations	0.00
E-Trailers	0.00
F-Uncontrolled LF	0.00
G-Sanitary LF	1,851,049.66
O & M Unit Cost (TL/ton)	**10.17**

6.3.1.3. Total Cost

The total costs were calculated by collecting the separately calculated costs for the central districts in Table 6.8. Investment costs accounted for approximately 58 percent of the calculated total cost. It should be noted that in the analysis carried out, it was accepted that the entirety of the landfill site was built in one go, keeping in mind the model originally created. The cost of 20 years for the central districts was calculated as TL 24.70 per ton.

Table 6.8 *NPV of total cost for the CDMs*

Total Cost	1,200,456,327.73
Total Collected Waste	49,866,234.12
Total Unit Cost (TL/ton)	24.07

6.3.2. Peripheral Municipalities

The four scenarios for the environmental districts, which were the main focus of this study, have been examined economically. The results of the review were presented in the following section under four headings. Scenarios in each section were evaluated by comparison.

6.3.2.1. CapEx (Capital Expenditure)

The calculations of the investment expenditures made for the scenarios were examined in two sub-sections. Initial investment costs include procurement and construction costs to be made in 2016. Total cost covers all investments to be made in the next 20 years.

6.3.2.1.1. Initial Investment Costs

According to the results of the economic analysis, Scenario-1 was the scenario with the lowest investment cost. This result was important in terms of economically demonstrating the reason why uncontrolled landfills were preferred by the district municipalities. This also explained the attitudes of developing or underdeveloped countries on solid waste management. The initial investment cost of Scenario-1 was so low that it depends on the assumption that the investment and operating costs were zero for the wild storage sites. The costs of "gathering" that constitute the initial investment cost of Scenario-1 are the same in Scenario-2 and Scenario-3. The distance of the common landfills to be made was the reason that the initial investment cost of the collecting process of Scenario-4 becomes more expensive. With the increase inthe transportation distance, the travel times have been extended and accordingly the number of trucks to be put into operation has increased.

Table 6.9 *NPV of calculated initial investment costs*

Initial Investment (TL)	**S1**	**S2**	**S3**	**S4**
	6,890,000.00	**27,790,000.00**	**51,160,850.00**	**45,329,900.00**
Total Collected Waste (Ton)	204,777.50	204,777.50	204,777.50	204,777.49
A- Collection (B+C)	6,890,000.00	6,890,000.00	6,890,000.00	9,314,000.00
B- Waste Bin	730,000.00	730,000.00	730,000.00	734,000.00
C- Trucks	6,160,000.00	6,160,000.00	6,160,000.00	8,580,000.00
D-Transfer Stations	0.00	15,200,000.00	0.00	800,000.00
E-Trailers	0.00	5,700,000.00	0.00	300,000.00
F-Uncontrolled LF	0.00	0.00	0.00	0.00
G-Sanitary LF	0.00	0.00	44,270,850.00	34,915,900.00
Investment Unit Cost (TL/ton)	**33.65**	**135.71**	**249.84**	**221.36**

Scenario-2 requires that each peripheral municipality had a transfer station, which was economically assessed. In the performed economic evaluation, Scenario-2 emerged as the second option with the lowest investment cost. In addition to the collection operations in Scenario 2, investments related to the accumulation and transfer operations were mentioned. Transfer stations constitute 54% of the initial investment costs of this scenario. The accumulation and transfer infrastructure required to transfer the solid wastes collected in the PMs to the regular landfills constitutes 75% of the initial investment costs for Scenario-2. The outcome has been analyzed within the framework of population projection. The population growth rates of the surrounding districts were low. In addition, the population of some PDs was diminishing with respect to projection. In this context, it was possible to dispose the solid wastes to existing SLFs through transfer stations, which can be built and operated in a short time. Considered by investment cost, Scenario-2 was seen appropriate for short term.

Scenario-3 was economically assessed for each PD municipality having a sanitary landfill (SLF) site. The highest value in terms of the initial investment in the evaluation made was in this scenario. The investment costs per ton of SLF were high. In addition, the population of some PDs was going to diminish according to population projection. The proposed system at this point was seen inefficient in terms of investment cost. There must be high population settlements for SLF to be affordable. This would reduce the marginal cost, where the cost per ton will be at a reasonable level.

In Scenario 4, municipalities were grouped by taking into account the population and geographical conditions. Sanitary landfills had been identified for the grouped municipalities. When grouping, it was regarded that the population was more than 100,000 and the distance between district and SLF was not longer than 40km. In this framework, the evaluation result was that the initial investment cost of Scenario-4 was higher than Scenario-2 and less than Scenario-3. The main reason for the result of this calculation was that the garbage collected in Elmadağ and Ayaş PM's was planned to be moved to Mamak and Sincan SLF's respectively. The use of these existing sites has reduced investment costs. Also, depending on the concept of marginal cost, the per-ton costs will be reduced in the areas to be built for grouped districts. Reduce of marginal cost was not taken into account in calculations. When 10 TL of value per tone was reduced by 10% for the setup of the SLF's during the calculation, the cost drops to 41,838,310.00 TL and when reduced by 15%, the initial investment cost drops to 40,092,515.00TL. Scenario-4 under these conditions was the second most economical plan after Scenario-2 when considered in terms of initial investment costs.

6.3.2.1.2. Total Investments

The total investment costs for all scenarios are given in Table 6.10. As in the initial investment costs, the investments made in addition to the collection process in the scenario also constitute the fundamental difference in the total investment costs. The accumulation and transfer infrastructure, which accounts for 75 percent of the initial investment costs of Scenario-2, accounted for 62 percent of total investment costs. When the Scenario-2, Scenario-3 and Scenario-4 were examined together, the proportion of the vehicles used in the transfer of solid wastes was increased, in other words; the share of the transportation investment has increased over time. It was observed that the difference between the scenarios decreases when the total investment unit costs examined. The difference between scenario-3 and scenario-4 was negligible. The difference between Scenario-2 and others has decreased.

Table 6.10 *NPV of calculated investment costs for PDMs*

	S1	S2	S3	S4
Total Investment, (TL)	**19,006,246.61**	**50,422,385.28**	**63,277,096.61**	**62,451,478.93**
Total Collected Waste,(Ton)	**4,423,013.56**	**4,423,013.56**	**4,423,013.56**	**4,423,013.55**
A-Collection (B+C)	19,006,246.61	19,006,246.61	19,006,246.61	26,053,508.95
B- Waste Bin	2,363,997.68	2,363,997.68	2,363,997.68	2,379,462.64
C- Trucks	16,642,248.93	16,642,248.93	16,642,248.93	23,674,046.31
D-Transfer Stations	0.00	15,785,568.82	0.00	680,000.00

	S1	S2	S3	S4
E-Trailers	0.00	15,630,569.85	0.00	802,069.98
F-Uncontrolled LF	0.00	0.00	0.00	0.00
G-Sanitary LF	0.00	0.00	44,270,850.00	34,915,900.00
Investment Unit Cost (TL/ton)	**4.30**	**11.40**	**14.31**	**14.12**

6.3.2.2. OpEx (Operational Expenditure)

Operating and maintenance costs constituted the second analysis variables of the scenarios. The expenditures required to operate the systems in the scenario have been examined under this heading.

Scenario-1 has the lowest operating cost, but compared to its total investment cost, operating and maintenance costs are two and a half times the total investment.

When the operating and maintenance costs of Scenario-2 were examined, the highest value belongs to this scenario. Scenario-2 has an operating and maintenance cost 10 times greater than other scenarios. When the components were examined separately, it was seen that the transfer costs have a share of 92 percent.

It was in the model framework that this high amount was directly proportional to the amount of solid waste to be transported and total transport distances.

Scenario-3 was the second most economical option. The main cost reason was the operation of landfills. The costs of the collection process were the same as Scenario-1 and Scenario-2. The second most expensive option was scenario-4. The Transfer Center planned to be established in Bala district in the scenario and the transfer to the SLF about 80 kilometers away from there increased operational expenses. The increase in the number of garbage trucks referred to in the total investment cost section indirectly increased the operating expenses of the collection operation.

It was seen that Scenario-2 is far away from economic value with a value of 369,57TL/Ton when it was examined for unit costs of operation and maintenance costs. Scenario 3 and Scenario 4 appear as options that should be examined in more detail with relative values.

Table 6.11 *NPV of calculated operation maintenance costs for PDMs*

	S1	**S2**	**S3**	**S4**
Total Operation and Maintenance (TL)	**49,806,548.52**	**1,634,607,837.48**	**114,939,698.35**	**141,330,405.59**
Total Collected Waste (Ton)	**4,423,013.56**	**4,423,013.56**	**4,423,013.56**	**4,423,013.55**
A- Collection (B+C)	49,806,548.52	49,806,548.52	49,806,548.52	71,239,393.91
B-Trucks	21,321,808.99	21,321,808.99	21,321,808.99	30,460,115.78
C-Worker	28,484,739.53	28,484,739.53	28,484,739.53	40,779,278.14
D-Transfer Stations	0,00	13,545,889.05	0.00	499,536.73
E-Trailers	0,00	1,506,122,250.08	0.00	4,129,503.60
F-Uncontrolled LF	0,00	0.00	0.00	0.00
G-Sanitary LF	0,00	65,133,149.83	65,133,149.83	65,461,971.36
O & M Unit Cost (TL/Ton)	**11.26**	**369.57**	**25.99**	**31.95**

6.3.2.3. Total Cost Comparison for the Scenarios

In this section, the total costs of the four scenarios recommended for the Ankara's MSW management system were compared. The total cost includes all the expenses calculated based on the population projected for twenty years (Table 6.12).

Table 6.12 *NPV of calculated total costs*

	S1	S2	S3	S4
Collection	68,812,795.13	68,812,795.13	68,812,795.13	97,292,902.86
Transfer Stations	0.00	29,331,457.87	0.00	1,179,536.73
Trailers	0.00	1,521,752,819.93	0.00	4,931,573.58
Uncontrolled LF	0.00	0.00	0.00	0.00
Sanitary LF	0.00	65,133,149.83	109,403,999.83	100,377,871.36
Total Cost	**68,812,795.13**	**1,685,030,222.75**	**178,216,794.96**	**203,781,884.52**
Total Unit Cost (TL/ton)	**15.56**	**380.97**	**40.29**	**46.07**

The analysis of Scenario-1 was to see the essentials of the solid waste system and to understand why similar scenarios were preferable for various local governments. The total cost of the scenario was equal to the cost of the collection and was considerably low compared to other scenarios.

Scenario-2 was the most expensive system among all options, when the total cost obtained after 20 years of projection was calculated. The total cost was calculated as 1,685,030,222.75 TL. The most costly part of the scenario is the transferring process. Apart from investment costs, operating costs of transferring seem to be the reason for this huge increase. This cost was mainly due to high fuel costs, which was the main item of transport costs. In addition, when examined environmentally, the environmental impact of vehicle fuels and emissions from fossil fuels to be used for transport must not be overlooked. Due to the length of the transportation distance, the amount of fuel to be used and the associated cost and pollution increased.

Looking at the total costs within the scope of the 20-year projection, Scenario-3 had emerged as the most efficient system in terms of economic sense. Scenario-3 has the lowest value in the total cost calculation even though the initial investment cost was high. In terms of costs, it offers an advantage in long term.

Scenario-4 had emerged as the second most efficient system in terms of economic sense. Optimization of transport distances and grouping the municipalities to minimize marginal costs reduced costs. The regular storage sites constitute half of the costs of the system in which they are created, and 97% of the remaining costs belong to the collection costs.

Unit costs were compared; it was seen that the calculated unit costs of Scenario-1 and Scenario-2 do not have meaning within this study. Unit prices for Scenario 3 and Scenario 4 were significant for 20 years when systems were considered as a whole and compared to unit prices for other examples in the literature.

6.4. Evaluation of the Economic Analysis Results Discuss

Scenario 1, which was incompatible with environmental law, loses its validity only after the Law 6360 enters into force, but it should not be forgotten that this law covers only the metropolitan municipalities. At this point, the other scenarios that offer more environmental solutions were the discussion. Environmentalist scenarios should not be addressed only on environmental impacts and costs, but also on the spatial development of settlements and the efficiency of municipal services.

When examined for 20-years of term within the limits of the study, the system examined in Scenario-2 under the current circumstances was far behind other options economically and environmentally. This option, which has a low initial investment cost, was advantageous to operate quickly but in 20 years the operating costs would be 97% of the total costs. The total cost of the scenario is 1.4 times of the cost of the solid waste management system of the central districts that have 90 percent of the population. On the other hand, it should be considered that the nearby region of the transfer stations considered to be installed in the existing wild storage areas may be subject to construction for 20 years. In such a case, the costs of relocation due to malodor and visual pollution will also occur in the developing regions. The greenhouse gases that leave the atmosphere due to the fossil fuels used by the trailers during the transfer process should not be ignored. Scenario-2 was not successful in terms of economical and environmentalist aspect, in other words it was weak in terms of sustainability. In addition, the problem of solid waste disposal in municipal services will not be solved on the spot and the intervention will not be possible in the event of difficulty.

Scenario-3 was the lowest cost investment option. Although the initial investment costs were high, the operating costs were low. It was clear that the sanitary landfilling is an environment friendly disposal method when taken from the environmental point of view. In the model it was thought that the sanitary landfill sites to be installed would be made where the existing wild storage areas were located. In these conditions, with the expansion of the settlements in the PMs, where the pace of development was high, these areas would be able to stay in settlement areas. The conversion of ULFs to SLF in residential neighborhoods will reveal unplanned choice of location when considering the possible expansions of the settlements for 20 years. In addition, marginal cost increases due to inefficient planning. From a point of view of scale economies, it would not be economical to make such high cost investments for small populations. If this issue is addressed in detail, the installation unit costs of regular storage areas may exceed the accepted value of 10 TL / ton in the study.

It was also important that the infrastructure of the existing system can be used in the new system.

In Scenario-4, unlike Scenario 3, the fact that SLF sites were settled out of settlements also reduced adverse effects on urbanization. United SLF fields could increase the land use efficiency. In addition to all these, specialized disposal facilities for solid wastes, which may have different characteristics for each zone, can be established.

6.5. Policy tools

Although municipal solid waste management is one of the services provided by local governments to the public, it should not be overlooked that the concept of municipal solid waste is an environmental problem that needs to be managed. For this reason, the policy tools that are revealed as a result of the analyzes are directed towards the environmental policies of Ankara Metropolitan Municipality. The concept of policy is defined as the principles and action plans that underpin the decisions and activities. Environmental policies are defined as the principles and preferences of the measures taken to protect and develop the environment and the objectives to regulate the relationship between society and the environment (Keleş, Hamamcı, & Çoban, 2015).

Among the scenarios analyzed, the tools that will enable the implementation of the scenario which is found to be the most economically feasible for the Ankara Metropolitan Municipality have been determined. However, the requirements of the Law No. 6360 and the concept of solid waste management system are briefly explained in order to better understand the identified tools.

6.5.1. Law Numbered 6360

With the enactment of the law, the population, the number of settlements and the surface area where the metropolitan municipalities are responsible for providing services have increased, and within the provincial borders, the authority and responsibilities of the provincial special administrations have been centralized and closed in metropolitan municipalities. However, the equipment, capacity, knowledge and scale understanding of metropolitan municipalities cannot be developed at the pace to keep up with this change. However, services such as public transportation, water and sewage, solid waste disposal and inspection, which are under the responsibility of metropolitan municipalities, have to be delivered to each settlement within the boundaries of the provincial administration. In the face of this requirement, metropolitan municipalities tend to maintain their usual form of service in the short term. However, it is necessary to adapt service delivery styles and to develop innovative approaches by taking into consideration the expanding service area in order to ensure efficient use of resources, efficiency and productivity in services.

6.5.2. The requirements of the Solid Waste Management System

The solid waste management system is a process that involves managing not only the disposal of waste after the emergence of waste from but also the reduction of the waste that will arise. Although the solid waste management systems are sensitive to the environment, the most effective and quick operation of the disposal system does not result in the most suitable environment. Good planning of all components of SWM systems and making all processes environmentally sensitive will make the system meaningful. At this point, pollution, such as air, soil, water noise must be taken into consideration, completely eliminated or minimized.

6.5.3. Determination of Policy Tools

With the entry into force of Law number 6360, infrastructure and capacity problems have emerged. However, since the law does not have the opportunity to perform the necessary analysis and development activities in a short period of time after the entry into force of the Law, it is observed that the current service provision approach is continuing to a great extent. This situation brought up short-term and hand-held approaches in many service areas. However, SWM requires the establishment of a process management that is the opposite of the situation as a system that will provide success in planning, coordination and long term success. Environmental policies can be classified into two sub-headings. These subheadings are called restorative and preventive policies. Restorative policies aim to eliminate the effects of harmful consequences on the environment. Preventive policies, on the other hand, aim to eliminate or mitigate impacts without allowing the emergence of concepts that will have a negative impact on the environment (Keleş et al., 2015). The policy instruments referred to in this study can be considered as preventive policies in an environmental and economic sense, as they are developed in the light of the next twenty-year period.

In the light of the data obtained within the scope of the study, as a result of the analyzes conducted in Ankara scale, it was determined that the solid waste to be produced in proportion to the increase in the current population of 5,270,575 living in 25,632 km2 of provinces will increase. The disposal of the resulting solid waste is the responsibility of the Ankara Metropolitan Municipality. At the present time, it is seen that the wastes collected at the provincial level for the solid waste disposal process have been carried to the landfill facilities in the management of the metropolitan municipality. In the analysis, it was predicted that reducing transport distances and taking into account economies of scale would produce lower cost and efficient solutions. For this reason, it has been decided that the study of the policy alternatives that take into consideration spatial and administrative changes, besides the existing solid waste collection methods of Ankara Metropolitan Municipality, is important in improving the service.

Considering these analyzes, it was considered that Ankara Metropolitan Municipality would use the following policy tools in the fight against solid waste problem.

P-1: Disposal of the waste at the site

Economic analysis for the city of Ankara revealed that the most costly component of the solid waste management system is the transport of solid waste. Transport costs need to be reduced to the optimum level, taking into account other components. Waste produced in the surrounding districts should be transported at short distances rather than transported to the disposal facilities located in the city center and disposed at the nearest point to the source.

P-2: Adoption of solid waste hierarchy

Particularly, it is necessary to encourage the adoption of solid waste hierarchy by taking into consideration the scattered settlement within the provincial borders and the population, which is included in the new post-law system and has gained the status of neighborhood. Public adoption of the solid waste hierarchy in settlements with low populations will reduce the amount of waste generated. Thus, the frequency of the service provided to these settlements can be reduced..

P-3: Solid Waste Unions

It would be acceptable that the solid waste unions of which economic modelling was made in Scenario – 4 and which was applied by Beypazarı and Nallıhan districts before the Law 6360 may become more efficient and effective by using the control coordination and knowledge of Metropolitan Municipality.

P-4 Reconsideration of administrative boundaries

Close-range districts within the administrative boundaries of different cities may establish solid waste associations. In this way efficiency can be increased by taking into consideration geographical conditions, distances and economies of scale instead of administrative borders drawn on the map.

P-5 Sanctions for households

By imposing sanctions on the separation at sources, providing the contributions of households to the solid waste system and accordingly, preventing the waste of labor force and time. In less populated places, the waiting times of wastes separated at the source will be increased without creating environmental pollution and the frequency of collection will be decreased

P-6 Zero waste target

By imposing the zero waste target, which is used by European countries, especially Germany, there should be the studies to arrange the system in this issue.

P-7 Deposit Model

By implementing the deposit model on all packaging materials, especially on plastic bottles, the direct separation of solid waste should be ensured by the city citizens and the pollution in the streets should be prevented.

P-8 Determination of solid waste Characteristics

The solid waste characteristics of each district should be determined. In this way, the new disposal facilities to be established can be customized according to the characteristics of the districts, thus can provide a more efficient service in economic terms.

6.6. Evaluation of Overall Results

This study is based on two separate bases. The first of these bases is the evaluation and planning of the solid waste service within the scope of sustainability in Ankara and the situation of the solid waste service provided by the municipalities within the scope of the Law numbered 6360 constitutes the second one. The number of studies available in the literature regarding the structure and economic modeling of solid waste management services is very limited. The closest example made in this context was made by Kısa (2015) in Istanbul. The author, who modeled the solid waste service of İstanbul economically, evaluated the efficiency of the system and the returns of the recycling by scoring the existing landfill sites. However, before this concrete work, Bilgili (2012) emphasized in his study that the use of economic and financial instruments and managerial tools together in the implementation of the Turkish environmental policy will demonstrate successful results. Özata (2011) conducted economic analysis for four different solid waste disposal scenarios for a solid waste storage facility in Istanbul and compared the costs of solid waste disposal types. As a result of the study, it was mentioned that the efficiency of solid waste management is a function of basic factors such as finance, human resources and policy. On the other hand, Battal (2011) mentioned that the current status is not at the waste management level of developed countries because so far the solid waste data was not identified very clearly and there has been the inter-agency task complexity in Turkey. Kaya (2013) has investigated the costs of existing solid waste system and the variables that affect these costs. As a result of the study, it has been pointed out that small-population local government units do not manage the resources economically in order to minimize the costs, and that interagency coordination and cooperation models will provide more efficient presentation of environmental services. Soysal (2015) added that it would be more appropriate to plan and locate the settlements that will be established in this subject considering the solid waste management services. Yetiş et al. (2015) compared the types and costs of solid waste management in 4 different scenarios in the study executed for Montenegro. Although this study is similar to the study conducted in Ankara, the issues such as choosing a place for solid waste disposal facilities have not been discussed. However, this shows the common point of solid waste management systems in terms of operating costs. In a study conducted by Demirer et al. (2006), they examined the solid waste management system in Ankara in the context of the life cycle assessment (LCA) concept under five different scenarios. The study carried out a solid waste management system with the least environmental impact for the city center of Ankara. However, after the Law numbered 6360, which was entered into force, the results of this study remained insignificant. However, in the study, it is environmentally important that the solid waste management plan mentioned in the form of separation, collection, transportation and storage is the best option.

Although there are many studies in the literature about the policy tools that form the basis of this study, because of the Law numbered. 6360 recent entered into force, the studies of this law and its implications are very limited. Bilgili (2012), in his study on Turkish environmental policy, emphasized the need to integrate economic and financial instruments and vehicles with the aim of raising environmental awareness as well as administrative tools to Turkish Environmental Policy. Xu et al (2013) argued that it would be appropriate to evaluate integrated policy instruments by addressing similar conclusions in his policy analysis for China. At the point brought by the new law, Orhan (2014) argued that the Law numbered 6360, enacted within the steps taken in the process of decentralization, brought about a centralized localization while providing nationalization in the national sense. Therefore, he pointed out that the provision and coordination of the services provided by municipalities, such as solid waste services, would be troublesome in terms of public administration.

CHAPTER 7

CONCLUSION

The concepts of settled life and urbanization brought about by modern society have brought many problems together with the developing technology. The problem of solid waste comes at the top of these problems. The responsibility for finding a solution against MSW problem in Turkey is given to the municipalities. Municipalities are held responsible for the collection, transportation and disposal of solid wastes produced by households. With the increase in population, the management of the growing cities started to be difficult and therefore, in 1984, the Metropolitan Municipality was established for a population exceeding one million. The metropolitan municipalities created the solution of the solid waste problem with the district municipalities which were within their borders. According to this sharing, the task of collecting and transporting were given to district municipalities and the task of disposal was assigned to metropolitan municipalities. The municipalities, which are outside the borders of the metropolitan municipality, continued the old method. In the rural areas, the problem of solid waste is solved by the special provincial administrations to take them to the nearest district municipal disposal facility.

With the Law numbered 6360 issued in 2012 and enacted in 2014, the area of jurisdiction of the metropolitan municipalities were extended to the provincial administrative boundaries and all districts were connected to the metropolitan municipality. With this new regulation, the municipal services, which are under the responsibility of Metropolitan Municipalities, have been taken to the provincial border. The disposal of solid waste collected within the provincial administrative boundaries was also given to the metropolitan municipalities under Law numbered 6360.

Within the scope of this study, the issue of how the solid waste management system of Ankara should be managed after the Law numbered 6360 was investigated. The research includes the economic analysis of four different scenarios created for Ankara and the results of economic analysis. The scenarios created were used only to analyze the status of municipalities under the responsibility of the Metropolitan Municipality after the Law. The municipalities that were under the responsibility of the Metropolitan Municipality before the Law were evaluated as a whole as Central Districts. Other districts, peripheral districts, evaluated in each scenario with different combinations. In the Scenario-1, the continuation of the existing system before the Law 6360; in the Scenario -2, the use of the transfer system developed by the Ankara metropolitan municipality for the implementation after the Law; in the Scenario -3, the establishment of a sanitary landfills to every peripheral districts; in the Scenario-4, the establishment of Sanitary landfills to grouped peripheral districts by taking into account the population and distance parameters, analyzed economically. These four scenarios were examined for 20 years according to 20 years of population projection.

Although Scenario-1 has already been withdrawn, it reveals why it is a preferred option in terms of low cost and ease of implementation. Despite the fact that the Turkish environmental law and the solid waste action plan are incompatible with the Scenario-1, the Law numbered 6360 has also become contradictory with the law of Metropolitan municipalities. However, results of the economic analysis of Scenario-1 has shown that the cost of collecting and transporting solid waste in the peripheral districts is high.

Scenario-2 was developed in the light of the information received from Ankara Metropolitan Municipality and ITC Consulting Inc. The solid waste system, planned for Ankara and started to be implemented, has been modeled and analyzed economically by transferring the solid wastes collected in the peripheral districts to the landfill sites in Mamak and Sincan through the transfer stations. In the economic analysis, the investment cost of the system is low and the quick installation will be put into service quickly. However, the operating costs of the system are quite high. The main source of this cost is the transfer of the collected solid wastes to the landfills in the city center. Net present value of the scenario is approximately TL 1,521,752,819.93 was approximately 1.200.456.327.73 TL more than the net present value (NPV) calculated for the central districts, where the more than 90% of city population is living.

Considering the operating costs of the components required for the transportation process and their long-term increase, the scenario does not produce economically sustainable results. Looking at the results of Scenario 2, it will not be possible to take the municipal services as equal to a wide geography as a result of the obligations arising after the law. The use of economies of scale presented within the justifications of the law and the infrastructure and technical facilities provided by the Metropolitan Municipalities to more population do not apply to this scenario. Although the total service population will increase and the opportunities will be delivered to a wider audience, it is also important how the service is delivered to the public and the infrastructure used. As is known, in a large part of infrastructure used for transportation, Turkey is foreign dependent country. Foreign dependency on oil, tire, vehicle and spare parts has been indexed to foreign exchange. This situation causes the infrastructure, which is planned to be constructed in this scenario, to generate high costs.

In Scenario-3, it was planned that each district has its own sanitary landfill. Although this system seems to be higher in terms of initial investment costs in the economic analysis, the total cost at the end of 20 years is quite low compared to Scenario-2. Considering the fact that the collection and transport infrastructure in the districts will continue to be used and only the regular landfill sites will be built, the initial investment costs will be reduced further. However, in the population projections, it was seen that the population of some of the surrounding districts has decreased. Considering the size of population to be serviced by landfills and the amount of solid waste to be disposed of, the decrease in population will increase marginal costs. In this case, the efficiency of the scenario will become controversial. In addition to this situation, the negative effects of these areas which will remain within the settlement area due to the development of the districts, may disturb the society. In the framework of the justification of the new law, it will be more effective to conduct municipal services from a single center, however, new disposal sites to be built in each district will have to be a representative of the metropolitan municipality. This situation is not in line with the concept of centralization of local administrations mentioned in the reasons of the law. In terms of service efficiency, it is healthier to perform service management on-site.

Scenario 4 is the second most expensive scenario in the scenarios studied. However, the cost amount is slightly above scenario-3. The fact that the collected solid wastes are transported away from the settlements, the municipalities' solid waste systems are combined, the economies of scale and the use of land in the field are the positive aspects of the scenario. Similar to Scenario 3, the use of existing system infrastructure will reduce the investment costs. In addition, the unit price of the landfill installation unit accepted in the model is reduced due to the scale economy created by the combined districts. Scenario-3, such as Scenario-4, cannot meet the rationale for governing from the center at the local level brought by the law, but it is possible to establish a system in which the Metropolitan Municipality will constitute less representative than Scenario-3.

As a result of the investigations and evaluations, Scenario 4 is the most appropriate option in the scope of this study in order to fulfill the obligations of the Law numbered 6360.

As a result of all the findings from the above-mentioned scenario evaluations, the following results can be presented in managerial terms.

Although Ankara is the capital of the country, it is still lacking in many issues. In the framework of this study, the most important problems are that the solid waste statistics are not kept and there are no composition studies. It is evident with the presence of “scavengers” that there is no competent control of relevant authorities on the solid waste system. It is seen that the new law tries to resolve them in spite of the scientific and technical implications of the municipality. Both Ankara Metropolitan Municipality and district municipalities do not have a complete knowledge of the quantity of services they provide.

This case which is evaluated in particular for Ankara is actually concerned with policy issues in Turkey. The lack of coordination in the policies, the inability to pass the legislation to the implementation sufficiently, and the lack of clear sharing of authority are the most important problems. The solid waste system examined within the scope of this study is just one of the services that municipalities are obliged to offer. With the abolition of the special provincial administrations, it is not clear how the services provided within and outside the municipal boundaries by the rural services and municipalities, which have been served for years, outside the municipal borders, will be met by the metropolitan municipalities on time.

Also within the scope of this study, the political boundaries of Ankara formed the boundaries of the study. However, for systems that are more efficient on the ground, such as solid waste management system, the political boundaries will be ignored and the inclusion of the provinces in the neighboring provinces of Ankara and the provinces with the optimum distance and population size will lead to more healthy results in terms of sustainability. Even within the scope of this developing technology and economies of scale work using concepts such as artificial intelligence implementation across Turkey more economical, long-lasting, and efficient will ensure a sustainable solid waste management system put forward. The political boundaries required for supervision and management have been re-assessed in the provision of municipal services such as solid waste management, drinking water supply, and waste - water management.

In the framework of Law No. 6360, the formation of a strong local government at the national level leads to the emergence of strong central administrations from the city scale. This situation emerges as a scale problem among administrations. Solid waste services provided by the municipalities should be localized within the framework of optimum sizes in order to provide them in a sustainable environment.

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