

Waste Source Separation Planning by Cost-Benefit Analysis in Tehran-Iran

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Abstract

The paper came up with a full cost-benefit analysis of Tehran's source separation program for beverage containers. It provides covered examination of the cost elements of this program of storage, collection, and the treatment costs of empty containers, as well as all possible benefits such as by savings through an alternative treatment costs (waste collection and landfill disposal), energy-savings, and externalities associated with used recycled materials, reduction of landfill volumes, import and export of the product, and the creation of new workplaces. This research only includes the variable of operating costs and utilized a wide variety of data resources. Particular critical issues are examined through several necessary approaches. The finding of this research mainly is that the Tehran traditional combinatorial program performance was proved economically worthwhile but was costly due to the fuel consumption in the collection of recyclable materials which was much higher than other programs. This paper distinctively analyzed the savings we could make from alternative source separation program. It revealed better savings than the usual hence showed that the combinatorial program is highly efficient. This source separation program shrinks the cost of the collection and treatment for municipal waste management system. In addition, the net benefits are seen positive for all types of source separation programs, plastic, and glass and metal and that source separation program is economically constructive for the economy of the nation.

Keywords: Waste management, Waste source separation, Cost-benefit, Waste planning, Operating costs

1. Introduction

According to Robert J, 2006, the concept of Cost-Benefit was defined as maximizing the present value of all benefits less that of all costs. Operating costs on the other hand is the expenses which are related to the day-to-day expenses incurred in running a business, such as sales and administration, as opposed to production. Also called operating expenses (Hillel Glaze, 2011).

In sound business planning, the calculation of operating costs is considered very important. It can seriously affect a business if the costs are not budgeted properly. The risk of a business to fail to maintain adequate funds to operate properly increases if they lack of planning. It is essential to bear in mind that actual expenses may vary from one country to another or even from one location to another thus the operating costs is not unique to any country. Jack M., 1989 define operating costs as expenses that relate to a business' operations. It can also be referred as the costs of operating a specific device or branch of a corporation. These costs usually fall into two categories of called fixed costs and variable costs, and a business may have more type than the other.

Expenses that tend to remain the same whether the business or device is inactive or operating at full capacity is called Fixed Operating Costs. The expenses include machinery leasing fees and employee salaries. This requires salaries to be differentiated from hourly wages. Flexible expenditures on the other hand are known as variable operating costs. These expenses vary based on different factors. Money dispensed on hourly wages, for example, can be adjusted by varying the amount of time recipients are engaged in labor (Abraham S, 2010).

The category of variable operating costs contains expenses that are incurred only occasionally. The examples are property maintenance and equipment repair, salaries or wages of personnel, raw materials, fuel costs such as power for operations, fuel for production, real estate expenses, including: rent or lease payments, office space rent, investment value of the funds used to purchase the land. These expenses can be very intricate to speculate, which requires a business adviser or consultant to perform such tasks. Many businesses also find it beneficial to maintain a budget for incidental expenses (Jack M., 1989).

The research entails several studies worked on various waste collections to be investigated such as (Shaw *et al*., 2006; Dahlén et *al*.2007; Rigamonti et al., 2010). Various waste management strategies studies (e.g. Calabrò, 2009; Koufodimos and Samaras, 2002). Several authors cost–benefit analysis (CBA) have developed for MSW management on examining the effectiveness of established MSW management systems (Haddix, 1975; Goddard, 1995).

Dewees and Hare (1998) stated different views which said deposit–refund programs (mainly aimed at reusable bottles) cannot be grounded on economic cost-efficiency. Doron Lavee (2010) on the other hand views curbside recycling programs as less costly than mandatory deposit–refund programs but on top of that, flexibility in implementation is encouraged to ensure the programs are applied with cost efficiently.

The significant results of this research are from the method itself whereby the savings from alternative treatment costs are taken care of in the recent paper. Lavee (2007) for example presented a significant cost savings element within the municipal waste management system, achieved due to the large volume of most beverage containers as compared to the average waste volume. The action of taking beverage containers out of the regular waste containers benefited the municipality to enjoy considerable savings in the stage of the waste management system that occurs within the municipality (consisting mainly of waste storage and collection).

The current fact shows that 7,000 tons per day in Tehran and about 2.5 million tons of wastes are produced annually with about 75% - 70% compostable and about 20-25% dry recyclable materials and the rest is 5% -10% funeral wastes. The collected dry waste can be reduced of the costs through the collecting and transporting the wastes as well as reduced the disposal in Arodkah disposal and processing center. An analysis in four regions of Tehran in order to clarify the cost-benefit in this includes 17, 20, 9 and 6 regions. The data collection was used from the traditional program related to region 17, door-to-door service with plastic blue bag program region belongs to region 20 and current program of region 9 and curbside steel wire bins program and steel wire bin belongs to region 6.

The data from Tehran municipality of metal, glass and plastic products has been used to form theoretical model and an empirical analysis for this research. The analysis focuses on the high volume/weight ratio of most of beverage containers. It proves a greater savings thus shows the combinatorial system to be of efficient than other studies stated in this paper.

2. Material and method

The optimization model is considering an economics-based analytical framework with the objective to minimize the cost by calculating all the quantifiable system benefits and costs at a specific time period. (Rober, J, 2006) stated that Capital recovery factors are used for economic adjustment when long-term investment of construction costs has to be uniformly or non-uniformly recovered over several short-term planning periods. The Cost-benefit analysis of the objective function begins by examining the costs of the source separation program including:

Total revenue =

$$\pm\sum_{k=1}^{n}(C_k - B_k) \tag{1}$$

C_k=cost in program k; B_k= income in program k

The summation of all cost components is defined by *C* which consists of:

$$Minimize\sum_{k=1}^{n}\left[Ct_k + Co_k + Cc_k + Cs_k\right] \tag{2}$$

Where: Ct_k = Station costs in program k; CO_k = Operation costs in program k; Cc_k = Collection costs in program k; Cs_k = Storage costs in program k and;

Total operating cost =

$$\sum_{(o\in k)}^{n}\left[L_{ok}P_{ok} + U_{ok}L_{ok}\right] \tag{3}$$

L_{ok} = The number of labor in program k; P_{ok} = Salary or wages of personal in program k; U_{ok} = Wear of personnel in program k and;

Total station cost = $$\sum_{s=1}\left[L_k P_k + R_{sk}\right] \quad (4)$$

L_k = The number of labor in program k; P_k = Salary or wages of personnel in program k and; R_{sk} = requirements (plastic bag or steel wire bins) in program k

The summation of all income components is defined by *B* which consists of:

Total waste source separation income =

$$Maxi \max \sum_{k=1}^{n}\left[W_{kl} P_{kl}\right] \quad (5)$$

L_{kl} = Weight of collected material L in program k; P_{kl} = Price of recyclable material L in program k

The total collection costs are expressed as linearly proportional to unit waste loading. Fixed charge structures are not employed through the formulation of total construction costs for the site selection and only involve the examination of variable costs. The average operating cost is not considered to be constant and the possible recoverable resources (i.e. material and energy) in those centralized facilities are of paper, glass, metal, plastics, bread, and petrol. The secondary materials were separated directly started from the households or via the curbside locations along with separate term correspond to the income of recycling contractor. The programs may not always be economic, hence the plus/minus sign is used in net–benefit expressions (Rober, J, 2006).

2.1 The municipal waste management

The municipal stage of the waste management system consists of the collection of waste from waste containers, and its subsequent transports to the waste transfer station (from which it is sent to landfill). The cost in this stage depends primarily on the volume of the collected waste. This is due to the fact that the most significant cost component of the municipal waste management stage concerns waste-collection cycle frequency. The frequency of collection cycles is determined by the time it takes for waste containers to fill up. The huge volume waste requires waste containers to fill up rapidly and thus require an increase in the collection cycle frequency.

The recent facts tell us that Tehran metropolitan region generates over 7,000 tons of solid waste which is collected daily using middle stations of 11 and 1413 collection vehicles. Twenty-two administrative districts have promoted household recycling programs in Tehran City. Aradkoh the regional sanitary landfill, the only existing landfill, is located at the eastern boundary of Tehran City. Currently, more than two and a half million tons of waste is annually generated in Tehran. The waste analysis that was carried out stated that 32% of dry material is recyclable. Several waste source separation trials have been conducted in Tehran recently and were divided into two groups which have been well documented.

2.2 waste source separation strategies

The waste source separation strategies are whereby different time points during the last few years with different containers and tanks for temporary storage of dry waste were given to the householders. Each of them according to the fitness function witnessed the advantages and disadvantages. The dry waste containers and temporary storage tanks that have been used in various programs are explained as follows.

- Traditional program (CS3)

The city which applied door-to-door collecting waste and purchased waste (bread and ferrous-metal) is using waste pickers of separate citizens. The waste pickers in this system, especially those of collecting paper and plastic recyclables from contaminated sources such as household garbage and hospital waste were negatively affected by the quality of recycled products collected. The equipment used in this method includes a wide range of handheld devices such as carts and pickup trucks. In this program, citizens participate in recycling material such as bread, glass and ferrous-metal from home and then selling them for cash or exchanging them for other materials and separated recyclable materials in the following ways:

At source using specific recycling centers and stores; returning waste to the producers and institutions and advertising it for sale or free collection in newspapers
Taking it to storage sites and making use of collection and transportation services provided by itinerant workers and by pickup from the door

- Steel wire bins program (CS2)

This program was carried out in district 1 of region 6 in 2002. The population is 30,000 people. The women were educated of 11,900 people. This district is of 5500 household units, 450 units, 300 office and 118 education units. The program used 2181 80-liter container, 462 120-liter container, 16 2400-liter container for collecting paper and cardboard, glass and plastic and 448430 kilogram was collected dry recyclable. The vehicles used 4 Nissan pickup trucks which performed during the day, 2 times every week. They collected dry recyclable material on the first month of about 253 kg and 2514 kg at the end of the month. The materials were then transferred to Saleh-Abad complex. The source separation per -capita was 84 gram in each time collecting with attention to 770 waste generation per-capita per day it concluded to 44% total dry waste. Figure 8 shows the composition of the collected materials and Figure 9 shows the costs of the program.

- Blue garbage bags program (CS1)

The blue garbage program was performed in 2003 in district 2 of region 20 educating the people to co-operate with the source separation program. This door-to-door educating program involves women by providing them with blue garbage bags for dry waste segregation. District 2 of region 20 is of 20 blocks with 20 thousand people and they were trained within a month in 4000 households. Their vector data were collected of their v address, name, age, education, occupation, spouse, family size, number of housing units and ownership status. This collecting program was held during the day and the actual time was announced to them later. The waste is collected 2 days in a week by door-to-door service. These citizens sold their recyclable material using a cart. Dry recyclable materials are collected manually with 2 Nissan pickup truck, 8 three-wheeled motor vehicle and 10 carts. The collected materials were then transported to recycling station. The compound of the station is 400 square meters with 180 square meters of covered space. The station is equipped with a chopper plastic and query paper. It is located at residual area, offices, organizations and schools with the storage bins. Figure 6 shows the composition of the collected materials.

- Current source separation program (CS4)

The national program for source separation program in Tehran started in 2006 which involved a single recycling corporation to handle all recoveries. The dry collection program for home, street and the side margins used the temporary storage tanks. The dry waste collected by hunters and recycling stations will be then relocated to the area. The waste is then collected by contractors or other intermediaries and sold to buyers who value recyclable material. The recycling station is responsible for this activity with the recycling contractors as the dry waste collectors. The area also provides initial processing of dry waste materials. The workers will collect the dry materials and deliver them to the station. Should any problem arise; the citizens can reach the contractor for recollecting the dry materials by calling 137.

3. Results

For the purpose of the current study, we will hold our cost-benefit analysis using the current treatment costs of the program. Hence our final estimation will constitute a lower bound for total potential net benefits of the program.

3.1 The operational costs

Table 2 shows an average net cost which includes salaries or wages of personnel and wear of the alternative costs which was considered as an operating cost for waste source separation. Tehran in 2006 has set that contractor is required to pay a salary personal, reach to 135 IRR per kilogram for door-to-door blue bag program, 340 IRR per kilogram in the steel wire bins program, 310 IRR per kilogram in the traditional program, and 168 IRR per kilogram in the current program of sending materials to middle station.

3.2The collection costs

Table 2 shows an estimation of the costs associated with the collection of dry recyclable material in public spaces (that is fuel cost per kg for each program). The following calculation assumes a minimum of 2 IRR per kilogram collection cost for door-to-door traditional program and a maximize of 978 IRR per kilogram collection cost for the current program and the next ranking collection cost 410 IRR per kilogram of steel wire bins program and 284 IRR per kilogram of door-to door garbage bag.

3.3 The station costs

Some of the current collectors who operates container collection stations (regional and local stations receiving containers from the public). The analysis of the costs for these programs reached the following conclusions: the transportation costs and rent or lease payments maximize to 130 IRR per kilogram of current program, 108 IRR per kilogram of steel wire bins program, and a minimum of 77 IRR per kilogram of door-to-door blue garbage bag, and 88 IRR per kilogram of door-to-door traditional program. Table 2 presents the estimation.

Table 1. The number container was recovered based on type of program

Beverage container type	Weight (kg/container)	Source of recovered container			
		Reference programs		Combinatorial programs	
		Plastic blue bag program	Steel wire bins program	Traditional program	Current program
		No. container per kg	No. container per kg	No. container per kg	No. container per kg
Large Plastic bottle (1/89 liter)	0.043	2E+05	1E+05	2E+05	93662
Can	0.263	19011	9610	1806	16777
Bottle glass	0.5	4000	2772	7546	1484

A large plastic bottle, can and bottle glass weighed 0.043, 0.263 and 0.5 kilogram respectively (USEPA) which is easy to calculate the numbers of containers in a program. Approximately the number of collected containers in the current program is more than other programs. The result appears in Table 2.

Table 2. Average total net cost of the waste source separation in each program (IRR/kg)

Source separation programs	Storage cost	Collection cost	Operation cost	Station cost	Total costs
CS1	164	284	135	77	660
CS2	17	410	340	108	875
CS3	0	2	310	88	400
CS4	186	976	168	130	1460

Table 1 presents the operation costs which related to source separation programs. The analysis of the costs concludes that the average net costs solely operating to collect public dry recyclable materials is about 1460 IRR per kilogram. The program received up to 4E+6 kilogram a month, and employs 116 workers (20 three-wheel drivers and 96 pickup truck drivers). The components also include curbside and door-to-door collection of dry recyclable material. The second-rank operation is the door-to-door blue bags program which shows the average net cost of about 787 IRR per kg and generally received up to 750.8 IRR per kg and summed up to 34570 kilogram per month and with 31 workers. The net cost of this traditional program with 400 IRR per kilogram was ranked the fourth that received up to 1E+05 kilogram per month, and employed 90 workers. A large plastic bottle (1.89 in volume) represented 0.043 kilogram weight (USEPA) per each container. It is easy to calculate the numbers of bottles in a program due to weight of the plastic collected in each program. With attention to operating cost of 1 kilogram recyclable material in each program showed the estimated cost for 1 bottle for each operation. The second rank for the total cost belongs to the current source separation program with 60 IRR per container then, of steel wire bins program with 72.7 IRR per container and the third and fourth rank with 27 IRR for door-to-door blue bag program and 17 IRR per container for traditional program. Table 3 shows the details:

Table 3. Average waste source separation cost per large plastic bottle (1/89 liter) in each program (IRR)

Source separation programs	Storage cost	Collection cost	Operation cost	Station cost	Total cost
CS1	7	12	5	3	27
CS2	0.7	17	14	4	72.7
CS3	0	0.086	13	3	16.086
CS4	7	41	7	5	60

A can resulted with 0.263 kilogram weight (USEPA). It is easy to calculate the numbers of cans in a program due to weight of the metal collected in each program. With attention to operating cost 1 kilogram of recyclable material in each program with estimation cost of 1 can for each operation. The first rank for the most operating cost belongs to the current source separation program with 382 IRR per can followed by steel wire bins program with 228.5 IRR per can and the third and fourth rank with 172 IRR for door-to-door program with blue bag and 104.53 IRR per container respectively for traditional program. Table 4 summarizes all benefits per single container.

Table 4. Average waste source separation cost per can in each program (IRR)

Source separation programs	Storage cost	Collection cost	Operation cost	Station cost	Total cost
CS1	43	74	35	20	172
CS2	4.5	107	89	28	228.5
CS3	0	0.53	81	23	104.53
CS4	48	256	44	34	382

A bottle glass resulted with 0.5 kilogram weight (USEPA). It is easy to calculate the numbers of bottles glass in a program due to weight of the bottle collected in each program. With attention to operating cost 1 kilogram recyclable material in each program with estimation cost of 1 bottle for each operation cost. The first rank for the of the operating cost belongs to current source separation program with 65 IRR per bottle then, of steel wire bins program with 54 IRR per container and the third and fourth rank with 44 IRR for traditional program and 38.5 IRR per bottle for door-to-door with blue bag program. Table 5 presents the estimation.

Table 5. Average waste source separation cost per bottle glass in each program (IRR)

Source separation programs	Storage cost	Collection cost	Operation cost	Station cost	Total cost
CS1	82	142	67.5	38.5	330
CS2	8	205	170	54	437
CS3	0	1	155	44	200
CS4	93	488	84	65	730

3.4 The value of recyclable material

Center and sold in material form to recycling plants. The value of recyclable material has been estimated here according to the actual sales data of Tehran municipality.

Blue garbage bag program has collected 80% bread followed by 8% plastic , 6% ferrous-metal , 4% paper and cardboard and 2% glass while steel wire bins program collected 67% paper and cardboard more than other dry recyclable materials and followed by 16% plastic, 7% glass ,6% bread and 4% ferrous metal.

The traditional and blue garbage bags programs has collected more than other recyclable materials of dry bread while steel wire bins program collected more than other recyclable materials of paper and cardboard which simplify that the current source separation program has collected more than other recyclable materials programs. The weight of collected dry recyclable materials in traditional program is 1E+05 kg/month and 3E+5 citizen of population of region 17 with 0.35 per-capita per month, collected materials in current program with 31184 kg/month and 4E+05 person population of region 9 has 0.07 per-capita per month, collected materials in blue bag program with 87800 kg/month and 4E+05 person population of region 20 has 0.21 per-capita per month, and collected materials in steel wire bin program with 40766 kg/month and 2E+05 person population of region 6 has 0.18 per-capita per month.

In Tehran, some regions are separated about 12 % recyclable materials by intake of source separation program with attention to composition of waste with 80% them was valuable and about 20% them was invaluable.

Table 6 shows the number, net value and price per container per kilogram of large plastic bottle, can and bottle glass due to weight of each container (EPAUSA).

Table 6. Price per container of recyclable materials (IRR)

Beverage container type	Weight (kg/container)	No. container per kg	Net value of container (IRR per kg)	Price per container
Large plastic bottle (1/89 liter)	0.043	23.25	3000	129
Can	0.263	3.8	1400	368.2
Bottle glass	0.5	2	400	200

Table 7 shows the price per container and was calculated income in each program. Income due to more collected dry recyclable materials in traditional program is more than current program in the rank and door-to-door with plastic bag has more income to door-to-door steel wire bins program.

Table 7. Income by number of container of recovered in each program

Beverage container type	Price per container	Source of recovered container			
		Reference program		Combinatorial programs	
		Plastic bag program	Steel wire bins program	Traditional program	Current program
Large plastic bottle (1/89 liter)	129	2E+07	2E+07	2E+07	1E+07
Can	368	7E+06	4E+06	7E+05	6E+06
Bottle glass	200	8E+05	6E+05	2E+06	296833

3.5 Treatment costs

The study in Tehran of its actual waste data resulted with the mixed waste has a weight/ volume ratio of 300 kg/m3, with average net treatment costs – including collection, transportation and treatment – of about 62,000 IRR/ton (volubility of 1800 million IRR per day) excluding administrative costs and retailer storage and collection costs.

These costs refer only to dumping waste in a controlled situation, spreading and compacted of waste in a thin layer to the volume of material (thickness about 2 m), cover the material with a soil layer with about 20 cm thick and 60 cm thick layer coating the waste buried

The average treatment costs are about 30,000 IRR per ton of collection, 15,000 IRR per ton of transport, 4,000 IRR per ton of operating and 13,000 IRR per ton of disposal (TMO, 2006). With attention to cost of 1 kilogram wet waste as the municipality has declared of the costs for operating programs and calculated based on costs per 1 bottle for each operation cost.

Table 8 shows an average treatment costs per container which up to 2.709 IRR, excluding the collection costs and the transportation cost. The operation cost and disposal costs for large bottles are about 9.0183 IRR per can and about 16.67 IRR per bottle for glass bottle. These costs were estimated only for containers of volume smaller than 1.89 liter.

Table 8. Average treatment cost per container at the waste management –by type of cost and container type (IRR)

Beverage container type	Weight (kg/container)	Source of costs				Net value per kg
		Collection cost	Transport cost	Operation cost	Disposal cost	
		30	15	4	13	62
Large plastic bottle (1/89 liter)	0.04	1.29	0.64	0.17	0.56	2.7
Can	0.26	0.34	3.94	1.05	3.42	9
Bottle glass	0.5	0.17	7.5	2	6.5	16.67

3.6 Cost-benefit analysis

This program has resulted positively in which more recycled material entering the production processes, thus reducing pollution created by these processes. For instance, the energy used to recycle aluminum is only 5% of the required energy to create new aluminum (Ackerman, 1997). In turn, these energy savings lead to the reduction of air pollution. Recycling reduces the demand for energy about 90-97 percent for aluminum, about 55 to 85 percent for plastics and about 4-32 percent for glass. It is reported that the burning of waste in the incinerator releases toxic fumes and dust into the air and worsens the air pollution. Therefore, recycling is one of the most effective ways to reduce fuel consumption due to carbon dioxide. The facts stated that recycling of glass can reduce 20 % pollutions, 95% aluminum and plastic 47 % as well as reduces mining waste by 80% of water consumption. In conclusion, the activity of recycling or waste preventing with the goal to prevent excessive use of natural resources has reduced the energy consumption and the amount if waste thus cut the disposal costs. Therefore, recycling or reuse of materials consumed causes a decrease in the consumption of raw materials and to compensate for the deficiency (Dupont et al., 1999).

The analysis as mentioned by Michael Todaro (2011) noted that the correlation between exports and economic growth and employment is a function of the national income. The percentage of the export of plastic is found to be equal to 2.76%. On the other hand, the relationship between industrial production and employment is reportedly positive but indirectly.

(Brenda et al., 1995) stated that the implementation of the law has led to the creation of hundreds of jobs in areas such as collection, sorting, transport and treatment of empty containers. Employment has always depended on the production and demand. The total imports of paper and plastic bags in Iran are relatively high thus it was treated as a potential additional benefit of the program, and does not incorporated into the main cost-benefit analysis.

Another benefit is the savings from the alternative waste treatment costs which comes from the recovered beverage containers that do not reach the waste containers. The treatment costs prove the possibility of savings for waste management process in the municipal level with the increased recycling in source separation program. The constraint to recycle collected beverage containers cause the reduction of amount of waste sent to the landfill thus lengthened the operation of the landfill. The matter shows great magnitude due to the bulky volume of beverage containers waste plus the fact which says most beverage containers take years to be recycled. The solution by opening a new landfill excludes the usage of lands within a great distance around the landfill.

Table 9 below presents the results of the savings from the alternative treatment costs. The estimation is obtained from the collection cost approach (estimated through a survey of local waste collectors). The final estimation of saving costs is calculated based on large plastic bottle (1.89 liter). The net value from the current program of collecting more plastic is ranked the first per kilogram. The traditional program and door-to-door program per large plastic bottles is ranked the second while the third rank is the steel wire bins program and steel wire bins.

Table 9. Saving costs value by large plastic bottle (1/89 liter) in the types of programs

Beverage container type	Type of program	Savings in alternative treatment costs				Net value per kg
		Collection cost	Transport cost	Operation cost	Disposal cost	
		1.3	0.65	0.172	0.559	2.681
Large plastic bottle (1/89 liter)	CS1	2E+05	1E+05	28800	93600	4E+05
	CS2	2E+05	80717	21524	69955	3E+05
	CS3	2E+05	1E+05	28856	93782	4E+05
	CS4	2E+07	8E+06	2E+06	7E+06	3E+07

The results obtained from saving in the alternatives of treatment costs were shown in Table 10 with the estimation for saving costs is calculated based on can fish. Net value from the current program due to collecting more metal is placed as the first per kilogram. The second rank for saving cost is the plastic blue bag program, the third rank is the steel wire bins program and steel wire bins and the fourth is the traditional program.

Table 10. Saving costs value by can container in the types of programs

Beverage container type	Type of program	Savings in alternative treatment costs				Net value per kg
		Collection cost	Transport cost	Operation cost	Disposal cost	
		1.29	0.645	0.172	0.559	2.7
	CS1	24524	12262	3269	10627	50682
	CS2	12397	6198	1652	5372	25619
	CS3	2329	1164	310	1009	4812
	CS4	2748152	1374076	366420	1190866	6E+06

The results obtained from saving in the alternatives of treatment costs were shown in Table 11 which the estimation for saving costs is calculated based on bottle glass. Net value from the current program due to collecting more glass is ranked the first per kilogram. The second rank for saving cost is the traditional program, the third rank is the plastic blue bag program and the fourth is the steel wire bins program and steel wire bins program.

Table 11. Saving costs value by bottle glass container in the types of programs

	Type of program	Savings in alternative treatment costs				Net value per kg
		Collection cost	Transport cost	Operation cost	Disposal cost	
Beverage container type		1.3	0.65	0.172	0.56	2.7
	CS1	5160	2580	688	2236	10664
	CS2	3576	1788	476	1549	7389
	CS3	9734	4867	1297	4218	20116
	CS4	256484	128242	34197	111143	5E+05

The funeral residual waste density is about 400 kilograms per cubic meter with attention to collected materials in each program. The burial trenches of about 25 meters in height leads to saving of the land area thus appear more than other programs. If every square meter of landfill of Kahrizak is 1,000,000 IRR, the saving land usage and the cost will be more than other program. Table 12 shows the saving costs and the benefits of programs.

Table 12. Saving costs and benefits of collecting of beverage containers for saving land filing

Type of program	Weight of beverage containers	Saving land use	Saving cost
	Kg/month	Square meters	IRR
CS1	14200	1.41	1,110,000
CS2	9294	0.92	1,410,000
CS3	11462	1.11	1,000,000
CS4	1220041	122	122,000,000

Table 13 shows the results from the cost-benefit approach with the profits according to types of the source separation programs. The estimation is resulted from the collection cost approach (estimated through a survey of local collectors) and in range with the values of the other two approaches. The final estimation shows the benefit of the deposit which is ranked the first with 1786 IRR per kilogram is the traditional program, the second rank with 1620 IRR per kilogram is the door-to-door with plastic bag, the third rank with 479 IRR per kilogram is the steel wire bins program, and the fourth rank with 245 IRR per kilogram is the current program. Table 13 shows the revenue of the blue garbage program is more than steel wire bins and the revenue of traditional program is more than current program.

Table 13. Cost-Benefit analysis in various source separation programs (IRR/kg) in 2006

Source separation programs	Income	Net cost	Profit
CS1	2122	497	1620
CS2	1252	773	479
CS3	2186	400	1786
CS4	1705	1460	245

5. Discussion and conclusion

This study was conducted to determine the most feasible recyclable materials management system in terms of its only-cost-benefit point of view. This was accomplished by using the cost-benefit as a tool to compare different source separation programs as follows:

CS1# door-to-door service with plastic blue bag and pickup truck

The co-operation of the citizens, the ability to produce plastic bags for recycling and to provide training along with the delivery of the bag is possibly pursued. This program shows the saving cost of collecting beverage bottles is more than other cost due to excessive fuel usage. The saving cost for transportation, disposal and operation was ranked respectively. The saving costs in this program is ranked the second. On the other hand, the disadvantages of this program are firstly, the expensive price to produce the bags, the problem rises in exchanging the bags, the excessive waste, foul use of the bags by the citizens as well as the separate service in the delivering the bags.

CS2# Door-to-door service with steel wire bin and pickup truck

The usage of the steel wire bins definitely attracted the citizens to co-operate with the programs. Moreover, it made it possible to produce plastic containers to recycle, provide training along with the delivery of the blue bag. The usage of steel wire bins on the curbside provides lifelong education and the ability to provide 24 hours services to the citizens. The usage of fuel made this saving cost of collecting of beverage bottles program is more than other costs. The saving costs for transportation, disposal and operation were rank respectively and this saving costs program is ranked the fourth. The disadvantages found in this program are firstly the high costs in preparing the containers and bins, requires more space, unattractive to the public, the maintenance costs issue, the collection service which is separated, the barrier crossing, the possibility of fire and robbery.

CS3#Door-to-door service with pickup truck+ Curbside sorting with hand cart wheels

This kind of service uses a hand cart for further inspection and provides respond from the citizens due to low speed, creates lack of air pollution, jobs opportunity and lack of investments. It also manages the collection in narrow streets and generally provides more advantages than other programs. This program is a saving cost of collecting of beverage bottles more than other costs due to more usage fuel. The saving costs of transportation, disposal and operation are ranked respectively. The saving costs in this program ranked the third. The disadvantages of this program are the barrier crossing due to slow speed, inelegance, and low numbers of handle cart wheels, and the necessity of using a large number of handles cart wheels, swiping problems in areas with high slope and finally the segregation of wet waste.

CS4# Door-to-door service with plastic blue bag and pickup truck +Buyback center +Curbside sorting with motor three wheels

The usage of a component program for source separation will raise the possibility and the benefits of several methods. The used of buyback center makes the possibility of more regular service and carrying out dry recyclable materials by the citizens. This saving cost program of collecting of beverage bottles is more than other costs due to the excessive fuel usage. The saving costs of transportation, disposal and operation were ranked respectively. The saving cost in this program was in the first rank. The disadvantages of this program are the investment required for designing and equipping the station, the lack of public acceptance for waste transference, and the possibility to accept waste from municipal services and the separation of wet waste.

Most of the net operation costs for the source separation program were related to CS2 that this is 2.2 times of CS4, 2.5 times the CS1 and 1.09 times the CS3. Most storage costs of the source separation were related to CS4 which is 10 times of CS2 and 1.5 times of CS1. Most net station costs of the source separation programs were related to CS4 that this is 1.2 times of CS2, 1.68 times of CS1 and 1.47 times of CS3. Most collection costs of the source separation program were related to CS4 with 2.38 times of CS2, 3.4 times of CS1 and 488 times of CS3.

This paper represents a complete cost-benefit analysis for Tehran source separation programs for beverage containers. The result portrays the fact that the programs are of great benefits to the national economy with the total benefits exceeding total costs by 50%. It also shows a clear preference for the source separation programs, which leads to waste reduction at the lowest costs. The comparison of the costs of such a source separation programs with its benefits (measured as savings in waste disposal costs and revenue of programs) resulted in 10% reduction in waste levels which have been economically efficient under the price structure considered.

Other than that, the savings in alternative waste treatment costs appear as one of the benefits of the program due to the ability for the municipality to run a more efficient collection and disposal system from the removal of recyclable waste from waste containers. It also provides the lowest economic value with the reduction of landfill volumes. Finally, the paper also promotes almost 41 million IRR in the current combinatorial program and about 300-500 thousands IRR per kilogram in other programs, including 10 % separated materials (metal, plastic and glass bottle). The funeral waste with high thermal value for energy production also appears as the benefit of this study.

The net costs of the source separation related to the current combinatorial program that this is 1.6 times steel wire bins program and steel wire bins, 2.2 times door-to-door with plastic blue bag program and 3.65 times traditional program. The income from the traditional program is 4.3 higher than the current combinatorial program, 3.7 higher than steel wire bins program and steel wire bins and 1.1 higher than the plastic blue bag program due to the lowest fuel consumption for the collection of recyclable materials and doesn't use storage containers. On average, the benefit in traditional program is about 5.465 higher than the cost, the benefits in door-to-door with plastic blue bag program is about 4.27 higher than the cost, the benefits in steel wire bins program and steel wire bins is about 1.62 higher than the cost and the benefits in current combinatorial program is about 1.28 higher than the cost, so that even if actual costs are 30% higher than our estimation, implementing the program would still be sensible. The results portrays higher potential savings than is usually assumed thus proves the traditional combinatorial program or door-to-door with blue bag reference program to be even more proficient than what has been found in many of the mentioned programs. The results of the study should be analyzed with its risk, environmental and social effects.

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