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Designing Green Reverse Logistics Network for Recycling of Solid Waste under Conditions of Uncertainty

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ABSTRACT

Today the reverse logistics is one of the major activities of supply chain management that include all physical activities associated with returned products (e.g, sets, recovery and recycling, disposal and demolition). In this regard, concern about the environmental impacts of business activities lead to interest in supply chain design that is environmentally friendly. This article takes into consideration to minimize the environmental impact beside minimize the total cost of the basic model and the inherent uncertainty of input data. The basic model is considered to be a model plan to design a reverse logistics as a part of the supply chain in order to minimize the total cost for recycling urban solid waste. In dealing with uncertainty a scenario-based approach is used and the proposed model has been solved using GAMS software.

1. Introduction

Logistics include a physical sector of supply chain and mainly the activities related to the flow of materials and goods from raw materials to final product stage, including transport, storage and so on. One of the new trends in logistics management is recycling or reuse of products. In this way, the products that reach the end of useful lifetime are purchased by the final consumer and after disassembly of a product's parts that is reusable, again returns to the life cycle in the form of Salvage products. Designing and implementing reverse logistics network for product returns, not only reduces inventory and transportation costs, but also will increase customer loyalty (Lee, Gen, and Rhee, 2009). In recent years, reverse logistics have attracted much attention from academia and industry. Environmental and economic reasons are behind this trend. Reverse logistics because of the many competitive advantages associated with them has gained the popularity. Environmental regulations and economic interests, consumer awareness and social responsibility to the environment in this area are essential stimuli (Bagheri-neghad, Kazemzadeh, and Asadi, 2013). You can mention saturated areas of disposal waste, global warming and the rapid depletion of raw materials as the main environmental concerns (Gupta, 2013).

However, concerns about the environmental impact of business activities lead to the requirements of the government and consumers are environmentally friendly. In this way, consumers and governments impress on companies to reduce the environmental impact of products and processes (Meade, Sarkis, and Presley, 2007). The driving forces are leading to attract a considerable attention by the researchers to environmental supply chain management in recent years.

In this regard, the recent attention to recycling products and materials has increased for environmental protection. In this area, reducing waste and wastage is a major concern in industrialized countries. The worrying is in situation which the countries of Economic Cooperation and Development (OECD, 1999) produced more than 5 billion tons of waste every year including agricultural and mining waste, construction and industrial waste from the process of energy, waste of water treatment and municipal solid waste. Meanwhile, the management of municipal solid waste (MSW) as a disposal for the public comes into contact with a high political profile (McDougall, White, Frank, and Hindle, 2002). And the growth rate of consumer civilization, the development of industry and technology, the rapid increase in population, having modern equipment life in the human societies, increasing supplies and the growing trend of solid waste production rates are the issues that have created a huge crisis in human society. In fact, growing population and consequently increasing the production of waste, having particular concern about the God-given resources' depletion and pollution of natural resources have prompted experts to put the issue of solid waste recycling programs at the top of the alternative waste disposal in recent decades. MSW management can be considered in reverse logistics issues (RLP) in the supply chain (Bautista and Pereira, 2006).

Historically, the health and safety of waste management have been a major concern and waste should be managed in ways that minimizes the risks to human health and it is still true (McDougall et al., 2002) In this context, reverse logistics network design as a part of supply chain planning is important. The design of these networks can have a positive effect on the objectives of the supply chain to reduce costs, the level of accountability and performance (Chopra, 2003; Shen, 2007).

What has been discussed in the article and considered as an innovation is to develop a mixed integer linear programming model in the field of environmental reverse logistics of recycling solid waste in terms of uncertainty that includes customer centers, recycling centers and centers for final disposal.

In this article, we review the literature to define the problem and the proposed model and computational results will be discussed. The conclusions and recommendations for future research are presented.

2. Review of the literature

Green supply chain network design literature suggests that environmental aspects in the design of the network are mostly considered from two main perspectives. First view is minimizing the environmental impact of the production process and recycling that directly relates with decisions of the location and construction of production facilities and recycling; and the second view is minimizing greenhouse gas emissions resulting from transport between the various facilities network with network design decisions. The results of the study can be found in table 1. It should be noted that other views have been taken into consideration on the environmental aspects studied, for example, (Devika, Jafarian, and Nourbakhsh, 2014), in addition to minimizing the environmental impact of product disposal at the final disposal (landfill) and maximizing environmental benefits resulting from the use of the product recovery, regeneration and recycling.

However, studies in the field of waste sets and disposal location show that most of them follow a certain process, so that using GIS software and data sets required including map of soil, ground cover achieve the number of candidate sites for the construction of the sets and disposal of waste. Then the techniques of multi-criteria decision making (MCDM) and taking appropriate measures in various fields of interest address the priority of candidate sites without the use of software and pre-defined and engaged measure. For example, Sidikouei et al. (1996) are the first ones to synthesize GIS and AHP in localization. They used AHP content space by using selective criteria to GIS maps to find the perfect place used landfill.

Table 1. Two main views on environmental aspects in the design of the network

Paper reference	**Minimizing the environmental impact of the production process / recycling (in connection with the decision to build production centers / recycling)**	**Greenhouse gas emissions from transport between facilities**
Dehghanian and Mansour (2001)	✓	✓
Pati, Vrat, and Kumar (2006)	✓	
Fonska, García-Sánchez, Ortega-Mier, and Saldanha-da-Gama (2010)	✓	
Paksoy, Bektaş, and Özceylan (2011)		✓
Wang, Lai, and Shi (2011)	✓	
Pishvaiei and Razmi (2012)	✓	✓
Kannan, Diabat, Alrefaei, Govindan, and Yong (2012)		✓
Chaabane, Ramudhin, and Paquet (2012)		✓
Pishvaiei, Torabi, and Razmi (2012)	✓	✓
Devika et al. (2014)	✓	✓
Bing, Bloemhof-Ruwaard, and van der Vorst (2014)	✓	✓

After June of 2000, Aldrandaly et al. (2003), Bronco et al. (2005), Roshani and Heidari (2007) used the integration of GIS and AHP to locate.

Tavares et al. and Sener et al. (2011), Kara and Doratli and Alexander and Associates (2012) after the appointment of the candidate sites used software GIS, techniques MCDM have studied priorities. (Aragonés-Beltrán, Pastor-Ferrando, García-García, and Pascual-Agulló (2010) and Ekmekçioğlu, Kaya, and Kahraman (2010) using MCDM techniques to prioritize candidates for predetermined sites.

As stated several fields including economic, social and environmental, appropriate criteria for each field are assessed for the priorities of sets and disposal sites; Table 2 summarizes these measures in the environmental field that have been used in different articles.

Table 2. Environmental criteria used to prioritize the construction of waste sets and disposal site

Environmental Criteria		
Distance from pipelines	Distance from floodplains	Rainfall in the region
Distance from the motorway	Distance from the beach	Thick of impermeable layer of soil
Distance from the main road	Distance from the Dam	The soil permeability
Distance from the railway	Distance from the irrigation canals	Areas on the seismic line
Distance from routes	Distance from surface water	Active fault zones
Distance from residential areas	Depth of groundwater	Active volcano regions
Distance from industrial centers	Distance from underground aquifers	Areas with layers of sedimentary rock
Distance from the protected areas	Distance from the forest	Active erosion and landslide areas
Distance from active mines	Distance from the natural habitat of plants	The structure of the Earth / lithology
Land usage	Distance from home to animals	Slope of the land
Wind direction	Distance from tourist areas	Distance from the natural springs
Traffic	Distance from recreational areas	Distance from the lake
Odor / noise	Distance from specific areas	Distance from the river
Population density	Distance from the cemetery.	Distance from the source
Landscape / Urban View	Space infrastructure	Distance from wetlands

Taken together what was said and inseparable and direct relationship of reverse logistics process with the issue of solid waste management, we worked to use common standards in each one of two topics that are affecting the environmental impact. In this regard, as seen in Table 2, environmental criteria used in prioritizing the sets and disposal site are driven from articles related to this topic, so that appropriate indicators and different from what was presented in table 1. In this paper, in order to provide appropriate environmental indicators of solid waste management issues and different from what has been stated; we are considering minimizing the environmental impact as well as the objectives of minimizing the total cost of the mixed integer linear programming model for reverse logistics network design in terms of uncertainty.

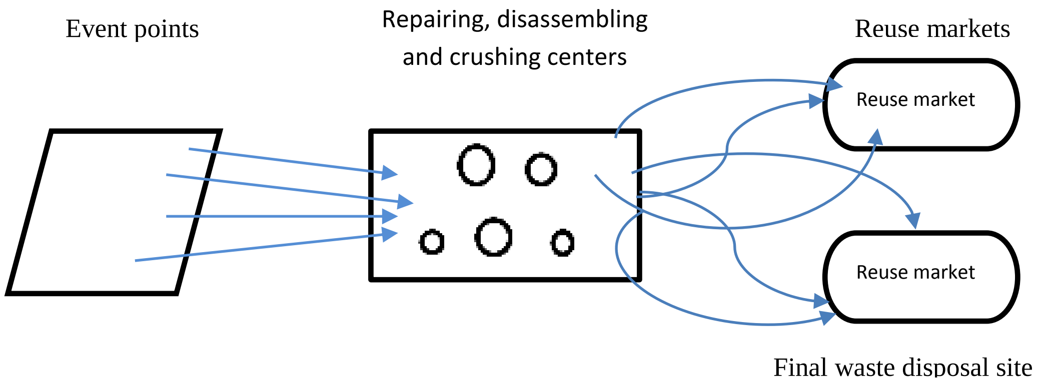

Fig. 1 Reverse logistics network (Chang and Yang, 2013)

3. Statement of the problem

Network studied in this paper is a reverse logistics for single-phase multi-product recycling urban waste taken from Chang and Yang paper (2013) including customer care centers, recycling and final disposal centers with the aim of minimizing environmental impact in addition to minimizing the total cost. Distribution of urban waste is composed of three sub-modes (Fig. 1). In the beginning, the great waste of event points arrived to a large waste recycling center. With regard to waste position, usable products, parts used or recycled materials are the valuable output of a large waste recycling center. They can be sent to reuse markets corresponding to profit and the final waste disposal site without a final value to be delivered. Because of the uncertainty in supply places a burden on network design stability will be discussed that we are ahead in the research.

However, to consider environmental factors relevant to the topic of solid waste management and different from what has been stated, the environmental criteria presented in Table 2 were evaluated.

In addition to considering environmental factors relevant to the topic of solid waste management and different from what has been stated, environmental criteria provided in Table 2 were examined the results of analyzes carried out show that a specific range of factors is uniquely associated with more solid waste (such as fruit peel and vegetable remains, etc.). According to the characteristics of more solid waste passing time leads to product more solid waste than their latex; leachate generated at disposal site by penetrating into the soil or earthquakes, volcanic activity, landslides and displacement and so on can enter groundwater and make irreversible environmental problems. Also smelling latex in addition to create problems for the residents leads to accumulate the birds that will cause to a problem for the region's airlines. Since this study is the large waste recycling household such as refrigerators, furniture, mattresses, carpets, etc., and the waste is producing latex over time, it is clear to select appropriate and accurate environmental criteria.

In order to provide the appropriate measures to investigate the matter, together with the issue of solid waste management and different from what has been stated, the maximum distance of the sets / disposal of waste from the nearest urban area, maximizing the distance of the sets / disposal of the nearest surface water (including water ponds, lakes, swamps, wetlands, coastal areas, dams and rivers) and maximizing the distance of sets / disposal of waste from the nearest main road (including roads, highways and freeways) are as the indicators of good environmental and innovative choice in this study.

The maximum distance of the sets / disposal of waste from the nearest urban area is because of the noise pollution generated from these locations. The maximum distance of the sets / disposal of waste from the nearest surface water are because of affecting by the processing operations and radiating hazardous gases such as the neon in recycling and disassembly of electric appliances such as refrigerators and impact of radiation on the surface that cause environmental problems and destructive effects on human health. On the other hand, maximizing the distance collecting / managing waste are considered from the nearest main road from the perspective of the urban landscape. The areas close to the main roads whether from the perspective of residents or travelers passing the roads' view or from the tourist perspective are high cultural landscape, so that we can locate recycling centers more carefully.

4. Model Assumptions

- There are two types of sources for the uncertainty in the supply of large garbage. One is unpredictable, e.g., location and time of return, and the other using historical utilization data (past) is anticipated, e.g., the amount and quality. In the study only events are investigated. Coordinates of large waste event points are considered as discrete random variables. The following is a scenario-based approach to model the conditions described.
- The number of scenario k is assumed to be in a large waste recycling network design. For the scenario k, large waste supply scenario scan be defined as $\{n_i^x\ (k), n_i^y(k)\ P_{in}(k)\}$.

Whereas n_i^x (k) and $n_i^y(k)$ indicate x-y coordinate point corresponding i, under scenario k in the supply of large waste. $P_{in}(k)$ represents the amount of large waste in the point corresponding i that is required to treat by the processing "n" mode under scenario k in the large supply of waste.

- Costs in recycling large waste systems are linear including the cost of land, facilities and equipment, processing and transportation.
- The cost of transportation from the candidate site S to final disposal site as well as the end markets is supposed as a constant.

- Candidate sites of recycling centers of large waste have been characterized.
- Markets of reuse and final disposal sites are given, because reuse of large waste of markets for reuse / recycling are not matured. On the other hand, the demand side is also not considered.
- Location of the final disposal sites is given.

5. Model Symbols

5.1. Sets

G: Index of goods that have been reused $g \epsilon G$

I (k): Index of the sets of large waste event locations under scenario of generation k of large waste $k \epsilon K$

Ns: Index of processing “n” mode set that is proper to launch in the candidate site S (for large waste recycling centers) $n \epsilon N_s$

Mg: Index of reusable commodity markets set g $m \epsilon M$

R: Index of final disposal sites $r \epsilon R$

S: Index of candidate sites for large waste recycling centers $s \epsilon S$

5.2. Parameters

B: A large number

C^1_{is}: Unit cost of transport between the incident site i and candidate site S for large waste recycling centers

C^2_{sgm}: Unit cost of transportation of reusable goods g between candidate site S for large waste recycling centers and market m for reusable goods g

C^3_{sr} : Unit cost of transportation between candidate site S for large waste recycling centers and final disposal site

C_{sn}: Large waste treatment unit cost by processing “n” mode at candidate site S for large waste recycling centers under processing

$d^1_{is}(k)$: Transport distance between the event point i and candidate site S for large waste recycling centers under scenario of generation k of large waste

d^2_{sgm}: Distance of transporting reusable goods g between the candidate site S for recycling centers and large market m for reusable goods g

d_{sr}^{3} : Distance of transporting between candidate site S for large recycling centers and sites for final disposal r

f_{sn}^{1} : Cost of launching candidate site S for large waste recycling centers that it will do a processing “n” mode

f_{sn}^{2}: Cost of equipment and setting up devices in processing “n” mode at candidate site S for large waste recycling centers

K: Number of scenarios in the scenario set of large waste

$P_{in}(k)$: Amount of large waste produced in event point i that is required to treat at processing “n” mode under scenario of generation k of large waste

U_{sn}: Maximum processing “n” mode of the candidate site S for large waste recycling centers

L_{sn}: Minimum processing “n” mode capacity of the candidate site S for large waste recycling centers

δ_{ng}: Conversion rate by the ratio of recycled products weight through processing “n” mode to great waste weight, $1 \geq \delta_{ng} \geq 0$; (or in other words, recycle rate)

$\delta_{n}^{'}$: Conversion rate that is the ratio of final waste weight created through processing “n” mode to the great waste weight. $1 \geq \delta_{n}' \geq 0$; (or the final disposal rate)

$w_{1}^{'}$: Coefficient (weight) of the importance of job creation index in the third objective function (minimization of environmental impacts)

$w_{2}^{'}$: Coefficient (weight) of indicator importance of distance of the nearest underground for the third objective function (minimization of environmental impacts)

$w_{3}^{'}$: Coefficient (weight) of population density of the nearest urban area in the third objective function (minimization of environmental impacts)

d_{sc}^{4} : Distance of candidate site S from the nearest urban area

d_{sw}^{5} : Distanceof candidate site S from nearest surface water w (w including ponds, lakes, swamps, wetlands, coastal areas, dams and rivers)

d_{sa}^{6} : distance of candidate site S from the nearest main road a (a including highways, highway and freeway)

5.3. Variables

$X_{isn}(k)$: Large amount of waste produced at the event point i by the processing “n” mode, candidate site S for large waste recycling centers under scenario of k generation of treating large waste

$X'_{sgm}(K)$: Amount of reusable items g at the candidate site S to treat large waste recycling centers and send to the market m under scenario of generation K of large waste

$X''_{sr}\ (K)$: Ultimate waste of candidate site S for large waste recycling centers r to final disposal site under scenario of generation k of large waste

$Y_{isn}\ (k) = \begin{cases}1\\0\end{cases}$: Variable 0 or 1 if the waste produced by event point i and the processing "n" mode has been set up at candidate site S for large waste recycling centers to treat under scenario of generation k of large waste1, otherwise 0.

$Z_{sn} = \begin{cases}1\\0\end{cases}$: Variable 0 or 1 if the processing "n" mode of large waste recycling centers S is launched 1, otherwise 0.

6. The proposed mathematical model

Symbols used in mathematical models examine the issue in above parts defined by using mixed integer linear programming model for integrated logistics network design in order to minimize the costs and maximize the social effects that are provided below:

$$\begin{aligned}\mathrm{Min} f_1 = &\sum_{s\in S}\sum_{n\in N_s}(f^1_{sn}\times Z_{sn}) + \sum_{s\in S}\sum_{n\in N_s}(f^2_{sn}\times Z_{sn}) + \frac{1}{K}\left\{\sum_{k\in K}\sum_{s\in S}\sum_{n\in N_s} c_{sn}\sum_{i\in I(k)} X_{isn}(k)\right\}\\ &+\frac{1}{K}\left\{\sum_{k\in K}\sum_{i\in I(k)}\sum_{s\in S} c^1_{is} d^1_{is}(k)\sum_{n\in N_s} X_{isn}(k)\right\} + \frac{1}{K}\left\{\sum_{k\in K}\sum_{s\in S}\sum_{g\in G}\sum_{m\in M_g} c^2_{sgm}\, d^2_{sgm}(k) X'_{sgm}(k)\right\}\\ &+\frac{1}{K}\left\{\sum_{k\in K}\sum_{s\in S}\sum_{r\in R} c^3_{sr} d^3_{sr} X''_{sr}(k)\right\} \qquad (1)\end{aligned}$$

$$\begin{aligned}\mathrm{Max} f_2 &= \left[\left(w'_1\times\sum_{s}\sum_{n} d^4_{sc}\, Z_{sn}\right) + \left(w'_2\times\sum_{s}\sum_{n} d^5_{sw}\, Z_{sn}\right) + \left(w'_3\times\sum_{s}\sum_{n} d^6_{sa}\, Z_{sn}\right)\right]\\ &= \sum_{s}\sum_{n}(w'_1 d^4_{sc} + w'_2 d^5_{sw} + w'_3 d^6_{sa})\, Z_{sn} \qquad (2)\end{aligned}$$

S.t.

Limitations of the current balance

$$\sum_{n\in N}\delta_{ng}\sum_{i\in I(k)} X_{isn}(k) = \sum_{m\in M_g} X'_{sgm}(k) \qquad \forall s\in S, g\in G, k\in K \qquad (3)$$

$$\sum_{n\in N}\delta'_{n}\sum_{i\in I(k)} X_{isn}(k) = \sum_{r\in R} X''_{sr}(k) \qquad \forall s\in S, k\in K \qquad (4)$$

$$\sum_{s\in S} X_{isn}(k) = P_{in}(k) \qquad \forall i\in I(k), n\in N, \forall\in K \qquad (5)$$

Capacity constraints of facilities

$$\sum_{i \in I(k)} X_{isn}(k) \leq U_{sn} \cdot Z_{sn} \qquad \forall s \in S, n \in N_s, k \in K \qquad (6)$$

$$\sum_{i \in I(k)} X_{isn}(k) \geq L_{sn} \cdot Z_{sn} \qquad \forall s \in S, n \in N_s, k \in K \qquad (7)$$

Rational allocation limitations

$$\sum_{i \in I(k)} Y_{isn}(k) \leq B \cdot Z_{sn} \qquad \forall s \in S, n \in N_s, k \in K \qquad (8)$$

$$Z_{sn} \leq \sum_{i \in I(k)} Y_{isn}(k) \qquad \forall s \in S, n \in N_s, k \in K \qquad (9)$$

$$X_{isn}(k) - B[Y_{isn}(k) - 1] \geq P_{in}(k) \qquad \forall i \in I(k), s \in S, n \in N, k \in K \qquad (10)$$

$$X_{isn}(k) + B[Y_{isn}(k) - 1] \leq P_{in}(k) \qquad \forall i \in I(k), s \in S, n \in N, k \in K \qquad (11)$$

$$\sum_{s \in S} Y_{isn}(k) \leq P_{in}(k) \qquad \forall i \in I(k), n \in N, k \in K \qquad (12)$$

$$B \sum_{s \in S} Y_{isn}(k) \geq P_{in}(k) \qquad \forall i \in I(k), n \in N, k \in K \qquad (13)$$

Domain Restrictions

$$Y_{isn}(k) \in \{0,1\} \qquad \forall i \in I(k), s \in S, n \in N, k \in K \qquad (14)$$

$$Z_{sn} \in \{0,1\} \qquad \forall s \in S, n \in N \qquad (15)$$

$$X_{ism}(k) \geq 0 \qquad \forall i \in I(k), s \in S, n \in N, k \in K \qquad (16)$$

$$X'_{sgm}(k) \geq 0 \qquad \forall s \in S, g \in G, m \in M, k \in K \qquad (17)$$

$$X''_{sr}(k) \geq 0 \qquad \forall s \in S, r \in R, k \in K \qquad (18)$$

In two parts of the equation (1), total fixed costs are including the costs of land and the total expected costs of transport and equipment. The rest of equation (1) is total expected costs of transport and operations. Equation 2 minimizes environmental impacts. Description of the indicators used in environmental purpose is presented in section 3.

Relationships (3) to (5) are the limitations of the current balance. Equation (3) shows the conditions under scenario k of large waste, total flow of large waste that needs to treat at the processing “n” mode and they are carried from all parts of the event i at the candidate site S as repairing, breakdown and disassembly, total outflows of goods reusable g to all the candidate site S reusable commodity markets is according to the δ_{ng} rate. Or the equation of balance equation goods reusable shows that the percentage of treated waste collected by the processing “n” mode and commodity reusable g turn multiplied by the total treated waste collected from the event i at the site S by processing “n” mode that are equivalent to the amount of reusable goods g to the market m.

Equation (4), under the scenario of generation k from the great waste total streams of waste large to be treated by the processing “n” mode, from all parts of the event i to site candidate S are carried to repair, collapse and disassembly centers that are equal to the external waste-finals The candidate s to all places of final disposal sites due to exchange rate δ'_n. Or in other words, it shows the balance of the final waste.

Equation (5) indicates the total waste collected in the event i treated by the processing n mode in all sites, the candidate must be equal to total waste of large production under scenario k in point event i to processing n mode.

Equations (6) and (7) are facility capacity is limited. These functions are reference models contingency planning. In fact, the amount allocated from the large waste are consistent into treatment capacity for processing “n” mode under generation candidate under scenario k of large waste.

Equations (8) to (13) are the limitations of the rational allocation. They can limit the allocation unreasonable large waste (destroy). Equation 8 ensures that large waste treated by the process n mode can be sent to the candidate site s only if it is decided that the processing of the candidate sites will be set up. (In other words, if the processing “n” mode launches at, as a result a large waste that need treatment in the event i (the processing “n” mode) need to be sent to the site).

Equation (9) prevents the unreasonable allocation, so that, if any large garbage are not allocated to waste recycling center on the site as great candidates for treatment by a special process under any scenario the generation of large waste, such processing mode should not be set up a large waste recycling center. (In other words: if any of large waste treatment at the event point i have not needed (processing “n” mode) they are not assigned to the site S, then as a result processing n mode should not be launched at site S).

Equations (10) and (11) determine that if the allocation was done $Y_{isn}(k) = 1$, all great waste at event point i have candidate site S to recycling centers great waste to be treated by the process n mode under scenario k generation of large waste. Note that these equations are extraordinary limitations of this model for network design.

This transport method is useful for tracking down true reverse logistics as a large waste. Equations (12) and (13) of unnecessary decisions are including the large garbage disposal if no scenario is prevented at this point under certain generation of large waste.

Equations (14) to (18) are range limitations. Equations (14) to (15) specify that $Y_{isn}(k)$ and Z_{sn} are variables 0 and 1. Equations (16) to (18) indicate that $X_{isn}(k)$, $X'_{sgm}(k)$ and $X''_{sr}(k)$ are non-negative variables.

7. Computational results

In this section, to demonstrate the applicability of the model, a sample problem is solved by software and solver GAMS 23.5.1 and using the CPLEX. After running the model to validate it the logical relationships was investigated between the variables. In fact, in addition to logical relations established between zero and one and continuous variables corresponding values of variables, with the logical model of performance parameters, for example, a site that was chosen for the construction, with an increase in fixed costs and solving this model, the site was removed from the selection. In addition to the parameters, established relationships restrictions were also reasonable.

It is necessary to mention that the method of determining the parameters of the basic model, according to an article on the study, of course, changes have been made, if necessary. Of course, in determining the parameters required for the development of model environmental dimension, the references (Devika et al., 2014; Eskandari, Homaee, and Mahmodi, 2012) and the information contained in this research have helped to investigate the matter.

The distance between the two places are orthogonal (metropolitan) and is intended to get the transport costs between the candidate sites and end markets as well as final disposal sites, distances between them is multiplied in the constant 15. Also, due to the uncertainty in the model parameters at uncertainty typically study business (as opposed to the uncertainty of the crisis) and cognitive uncertainty (as opposed to random uncertainty) is to deal with the uncertainty of the model, the scenario-based planning is random. In this regard to deal with uncertainty in the location of large household waste in the event, four scenarios has an equal chance to examine the values used in the model. After solving, the objective function value for the basic model is equal to 40701105 and the proposed model which examines the environmental aspect besides minimizing the cost is equal to 67835910. Then comparisons between the answers of basic model and environmental model consider the minimum cost.

8. Analysis of Results

It is clear that the objective function value for proposed model is much more than basic model; in fact, the costs that companies need to protect the environment is undeniable and on the economic direction it might be higher in some cases of economic benefit to direct and indirect income in the organizations. But it is important that the environmental aspect should not be viewed only from the economic point of view but protecting the environment has essentially great value, this value can be much higher than the economic benefits. Because if you do not pay attention to this aspect, the survival of the human species will be at risk and it is far more important than economic benefit. In other words, perhaps the difference between the values of the objective function based on the proposed model represents the cost the company pays for environmental protection. The difference between the values of the objective function of the application is important for two reasons:

(1) Organizations will be able to provide the difference in cost, effort and performance in order to protect the environment report to their stakeholders;

(2) States given the role of governing itself has an incentive to protect the environment and public subsidies to companies and organizations. The index is a good measure for determining the allocation of state subsidies. In this regard, in many countries, including Iran, the states offset costs for companies, by determining the policies and incentive benefits to support organizations working to protect the environment.

About the values of parameters the values (Z_{sn}) noted that in both the basic and proposed models, the same values are reported in Table 3. Perhaps the reason of these same values can be stated according to the values of the parameters in the model has been developed from several sources, the probability that the selected intervals for the parameters are not compatible.

To test the accuracy of the claim and the right of proposed model, one of the parameters in the objective function that is a positive factor is selected. As a rule, the increase in the objective function of proposed model which is the objective function minimization, the values of variables must have a significant change. For this purpose, we have multiple parameters of the distance from surface waters and these values did not change the basic model which was reasonable. Regarding the parameters of the basic model, there is no surface water in the objective function (minimizing objective function's total cost of the basic model included); but the values of the parameters in solving the proposed model with objectives take into account the environmental aspect, along with the minimum of total costs a significant change as samples obtained values (Z_{sn}) are presented in Table 3.

Table 3. The results driven from Z_{sn} for the basic and proposed model

$\mathbf{Z_{sn}}$			
Z_{11}= 1	Z_{13}= 1	Z_{15}= 1	Z_{23}= 1
Z_{31} = 1	Z_{35} = 1	Z_{52} = 1	Z_{54} = 1

Table 4. The results driven from Z_{sn} for the model proposed after changes to the parameters of the distance from surface water

$\mathbf{Z_{sn}}$				
Z_{15}= 1	Z_{23}= 1	Z_{41}= 1	Z_{52}= 1	Z_{54}= 1

Given the above, maybe if selected intervals for these values are closer to reality, it may be more possible to achieve realistic results. Since the other variables in the model were adopted by different amounts due to the large volume of them. On the other hand, there was no article in the field of reverse logistics network for recycling urban solid disposal.

9. Conclusion

This article was created on the basis of concerns about the environmental impact in the world, national needs and goals of its strategic documents, as well as gaps in the relevant literature, the environmental aspect of the issue of reverse logistics network design is discussed. Also, considering the importance of the environmental impact of the management of products' lifetime, in reverse logistics network design considering the issue of solid waste management and the common characteristics different from what has been stated; for a random network in the field of recycling of household waste from the paper of Chang and Yang (2013), in addition to minimize the total cost, minimizing adverse environmental impacts are considered. Increasing the value of the objective function in the model than the basic model indicates that the costs that companies incur to protect the environment are undeniable and in terms of economic direction in some cases the cost of direct and indirect economic benefits will be gained more for organizations.

In this regard, since the governments with regard to the role of government always allocate subsidies incentives in line with environmental protection companies and organizations, the index can be a good measure to determine the amount of government subsidies that could be considered in future research topics. Determining subsidies and government loans are the issues of future researches and on the other hand, taking into account the social dimension as one of the goals of developing model and multi-period network and taking into account the uncertainty in the amount, timing and quality of the product returned in reverse logistics network design.

10. References

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