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Financial Planning of the Garbage Disposal Plant Using Mathematical Model

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Abstract: It is known that urbanization, increase in population, unhealthy waste disposal practices, change in lifestyle and change in food habits are mainly responsible for increasing of wastes. Unplanned city faces the problem of huge volume of wastes generation. The increase in wastes leads to environmental pollution. Proper management of wastes is essential to keep environment healthy. Many of the countries are not adopting the proper waste disposal practices. A vendor who collects these wastes, converts the wastes into useful by-products and gets the profit by selling these by-products. Vendors from various companies buy varieties of wastes according to their need and manufacture new products from that waste. Their requirement depends on what type of product they produce. Their production depends on demand in the market. Business of disposal unit is a big challenge because unpredictable changes take place in the market often. We formulate pre-emptive goal programming model by considering some of the important goals to get the most profit. The study deals with goals like maximizing the sales income, minimizing the collection expenses, minimizing the transportation cost, minimizing salary expenses, minimizing the general expenses, maximizing profit of the unit. The study is an attempt of proper financial planning of garbage disposal plant using goal programming approach which is one of the optimization techniques. Proper financial planning will make sure the profit of the unit. The use of TORA Software helped us to find the solution easily.

Key words: Goal programming, priorities, deviational variables, underachievement, overachievement, vendor, optimization

INTRODUCTION

As we generally understand waste is an unwanted material. We need to dispense with such unwanted material at the first instance. As we don't have any intention to use such a waste material in future, accumulating them without their disposal causes several hindrances be it space constraints or unhygienic and unhealthy surroundings to name a few. Spurt in the growth of population, unplanned growth in cities, extension of city limits without concern to practical difficulties, aping western lifestyles including food habits, unconcerned, avoidable and excessive use (rather misuse) of renewable resources are a few of the reasons for increase of wastes. When the scenario is such causing/generating lot of wastes to keep better conditions for living, the wastes, so, generated need to handle efficiently and disposal appropriately. Failure in taking such steps or lackadaisical approach of the citizens or from the authorities concerned would be harmful for the health and hygiene standards further causing sickness, diseases, etc. As a result such a scenario in any society reverses the growth and thereby affects standard of living. This is the main reason about why we should find proper methods for disposal of waste. The shortlisted method should not only help in efficient disposal and clearing the stock of waste/garbage, etc. but also generate by-products, generate job opportunities, control pollution, keep natural resources, protect environment apart from contributing for growth of economy of the country. With such an efficient way of disposal if opted, it will automatically give for sustainable development. Any step/method which aims at preserving the natural resources and that protects the environment by reducing create of waste, contributing towards sustainable development. Keeping this understanding in view, any efficient way of waste disposal which positively contributes as enlisted above would be part of efforts towards sustainable development. Sources of generation of wastes are mainly residences (homes, hostels), hotels, commercial establishments, schools, colleges, vegetable markets, shopping complexes, temples, parks, roads, etc. Garbage disposal unit collects and disposes the wastes and segregate them into wet waste and dry wastes. Dry

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wastes are mainly plastic, glass, metals, wood, paper, tetra pack, etc. Demand of these wastes are in present scenario is very high, since, we can get useful products after recycling. Thus, we can decide wastes are valuable if it addressed and treated properly. Vendors of different waste management companies procure these wastes result in profit of garbage disposal plant. In present scenario selling of wastes is a profitable business. In today's world, fabric from plastic, liquid to gold, solid waste into fuel, power generation, extraction of precious and other metals from e-Waste are green business. By this, maximum revenue obtained by the unit at the same time it also helps protect the environment and society. We can generate power from wet garbage. Categorized and recycled plastics generate useful materials like plastic bowls, mugs, buckets, toys, chairs, etc., categorized and plastics are mainly pet bottles, milk covers, high density plastic and low density covers, etc. About 80% of recyclable plastics are possible to reuse. But plastic tars generated from 20% of the remaining non-recyclable plastics. New products like car parts, drainage pipes, bowls, mugs, etc., generated by moulding plastic resins. 100% use of paper wastes is possible by recycling process. Recycling of newspaper helps in making wrapping paper and newsprint. If glass wastes are reheated and remounted and it leads to new products like new glass containers, bowls, glasses, etc. Metals are also one categories of the dry wastes and metals are of many varieties like iron, aluminium, copper and steel, etc. Used metals are of lesser density. Produce of thin sheets, car body parts, etc. is possible after recycling. Recycling of aluminum leads to many useful products like aluminum thin sheets, foil, packing boxes, window frames, etc.

Literature review: Application of transportation linear programing algorithms to cost reduction in Nigeria soft drinks industry is explained as by Salami (2014). By Ekezie and Desmond (2013), application of goal programming in budgetary allocation is explained goal programming approach for food product distribution as by Hassan and Ayop (2012) helped us to frame the goal programming model. Sen and Manish (2012) explains, the goal programming approach to rubber plantation planning in Tripura. Goal programming model to rubber tea intercropping management is developed as by Sen and Nandi (2012a, b) to formation GP Model to rubber plantation in Tripura. By Jyothi *et al.* (2016), goal programming model is developed for optimal solution for distribution of segregated wastes in garbage disposal unit. Jyothi *et al.* (2017) refers to the formation of goal programming model for planning of disposal of wastes in garbage disposal unit. Literature survey of application of goal programming is as by Ghanashyam and Vatsal (2017). Optimization of university resource management through goal programming approach is explained by Vatsala *et al.* (2011). Dynamics and fuzzy logic method for controlling Quad copter is explained as by Syam (2016).

Study of the current problem: In the initial stage of proper disposal plan, the collected wastes segregated as wet waste and dry wastes. Further, wet wastes recycled and converted it bio-fuel and organic compost and wormy compost. Dry wastes segregated further and it includes mainly papers, plastics, wood, metals, glass and tetra packs, etc. Vendors from different companies procure different types of wastes according to their need. Their requirement depends on what type of product they produce. Their production depends on demand in the market. Different types of wastes considered are wet garbage, plastic, tetrapacks, paper, glass, wood. This study elaborates the disposal of collected wastes by deriving most benefit.

In this study, our study involves statistical data of Ward No. 151 (Koramangala) sub-division under BTM layout, Bangalore Division. In this unit total quantity of waste generation per day is 20.75 tons. Wastes are collected from 17497 number of houses, 741 commercial establishments, 19 small temples, 5 large temples. Primary collection costs of this unit is Rs. 7,07,565/per month, transportation cost is Rs. 5,34,212/per month, Salary charges Rs. 2,32,573/per month. Out of the total quantity of wastes collected 20.75 tons, wet garbage collection is of 12 tons, dry garbage is of 8.75 tons. Goal programming technique is used to maximize the profit of the unit.

MATERIALS AND METHODS

Methodology adopted for our study is gathering primary and secondary data. Review of the literature provided an overview of factors affecting waste management systems. Data gathered by various disposal units in and around Bangalore helped in our study. statistical data collection is from one of the units in Bangalore has taken into account. Recycling process and details of production bi-products collected by visiting more than 10 disposal wards in Bangalore. Review of literature also helped me to develop goal programming model to find the best solution.

Model development for the current problem/goal formulation: Objectives of our study involves maximizing the sales income, minimizing the collection expenses, minimizing the transportation cost, minimizing salary expenses, maximizing profit of the unit, minimizing the

general expenses and finding the ideal solution. The said objectives treated as goals and goal constraints formulated for the goals.

Goal 1: Maximize the sales income of wastes:

$$\sum_{i=1}^{6} S_i x_i \geq T_s$$

Where:
S_i = The sales income associated with each waste
x_i = No. of units of different types wastes collected
T_s = Target cost of sales income

$$\sum_{i=1}^{6} S_i x_i + d_1^- - d_1^+ = T_s$$

Where:
d_1^- = Under achievement from the maximum sales income wastes
d_1^+ = Over achievement from the maximum sales income wastes

Goal 2: Minimize the collection expenses:

$$\sum_{i=1}^{6} C_i x_i \leq T_c$$

Where:
C_i = The collection cost associated with each waste
x_i = No. of units of different types wastes collected
T_c = Target cost of sales income

$$\sum_{i=1}^{6} C_i x_i + d_2^- - d_2^+ = T_c$$

Where:
d_2^- = Under achievement from the minimum collective expenses of wastes
d_2^+ = Over achievement from the minimum collective expenses of wastes

Goal 3: Minimize the salary expenses of labour and supervisors:

$$\sum_{i=1}^{6} L_i x_i \leq T_L$$

Where:
L_i = The labor and supervisors cost associated with each wastes
x_i = No. of units of different types of wastes collected
T_l = Target cost of labor and supervisors:

$$\sum_{i=1}^{6} L_i x_i + d_3^- - d_3^+ = T_L$$

Where:
d_3^- = Under achievement from the minimum salary expenses of wastes
d_3^+ = Over achievement from the maximum salary expenses of wastes

Goal 4: Minimize the transportation cost:

$$\sum_{i=1}^{6} T_i x_i \leq T_t$$

Where:
C_i = The transportation Cost associated with wastes each other
x_i = No. of units of different types of wastes collected
T_t = Target transportation cost:

$$\sum_{i=1}^{6} T_i x_i + d_4^- - d_4^+ = T_t$$

Where:
d_4^- = Under achievement from the minimum transportaion expenses of wastes
d_4^+ = Over achievement from the maximum transportation expenses of wastes

Goal 5: Maximize the profit of waste product:

$$\sum_{i=1}^{6} P_i x_i \leq T_p$$

Where:
P_i = The profit associated with wastes each other
x_i = No. of units of different types of wastes collected
T_1 = Total profit target

$$\sum_{i=1}^{6} P_i x_i + d_5^- - d_5^+ = T_p$$

Where:
d_5^- = Under achievement from the maximum profits of wastes
d_5^+ = Over achievement from the maximum profits of wastes

Goal 6: Minimize the general expenses of the unit (general expenses include street cleaning, water expenses and electricity expenses of the unit, etc.):

$$\sum_{i=1}^{6} G_i x_i \leq T_G$$

Where:
G_i = The profits associated with each other
x_i = No. of units of different types of wastes collected
T_t = Target of general expenses

$$\sum_{i=1}^{6} G_i x_i + d_6^- - d_6^+ = T_G$$

Where:

d_6^- = The under achievement from the minimum general expenses of wastes

d_6^+ = The over achievement from the minimum general expenses of wastes

Priority levels are taken as follows:

- P1: maximizing the sales Income of the waste
- P2: maximizing the profit from each waste
- P3: minimizing the expenses of collection
- P4: minimizing the cost of transportation
- P5: minimizing the salary expenses of labours and supervisor
- P6: minimizing the general expenses of the unit

Achievement function:

$$\text{Minimize} = P_1 d_1^- + P_2 d_5^- + P_3 d_2^+ + P_4 d_4^+ + P_5 d_3^+ + P_6 d_6^+$$

Constraints equations; sales income constraint:

$$S_1 x_1 + S_2 x_2 + S_3 x_3 + S_4 x_4 + S_5 x_5 + S_6 x_6 + d_1^- - d_1^+ = T_s$$

Collection expensess constraint:

$$C_1 x_1 + C_2 x_2 + C_3 x_3 + C_4 x_4 + C_5 x_5 + C_6 x_6 + d_2^- - d_2^+ = T_c$$

Salary constraint:

$$L_1 x_1 + L_2 x_2 + L_3 x_3 + L_4 x_4 + L_5 x_5 + L_6 x_6 + d_3^- - d_3^+ = T_L$$

Transportation constraint:

$$T_1 x_1 + T_2 x_2 + T_3 x_3 + T_4 x_4 + T_5 x_5 + T_6 x_6 + d_4^- - d_4^+ = T_t$$

Profit constraint:

$$P_1 x_1 + P_2 x_2 + P_3 x_3 + P_4 x_4 + P_5 x_5 + P_6 x_6 + d_5^- - d_5^+ = T_p$$

General expenses constraint:

$$G_1 x_1 + G_2 x_2 + G_3 x_3 + G_4 x_4 + G_5 x_5 + G_6 x_6 + d_6^- - d_6^+ = T_G$$

RESULTS AND DISCUSSION

Statistical evaluation: Let us say with minimum garbage collection of various types, we want to meet the requirements. For example, what is the minimum set of garbage weights that will give us sales income more than 100 lakhs, collection expenses <8 lakhs, salary expense <20 lakhs, transportation cost <8lakhs; profit more than 60 lakhs, general expenses <10 lakhs. Thus, target values are as followsi) sales income 100 lakhs collection cost must be within 8 lakhs, salary expenses must be within 20 lakhs, transport cost must be within 8 lakhs. Profit must be increased to 60 lakhs. General expenses must be within 10 lakhs. The equations related to the above data are framed where x_1-x_6 No. of units of wet garbage, plastic, tetrapack, paper, glass, wood, collected in the units.

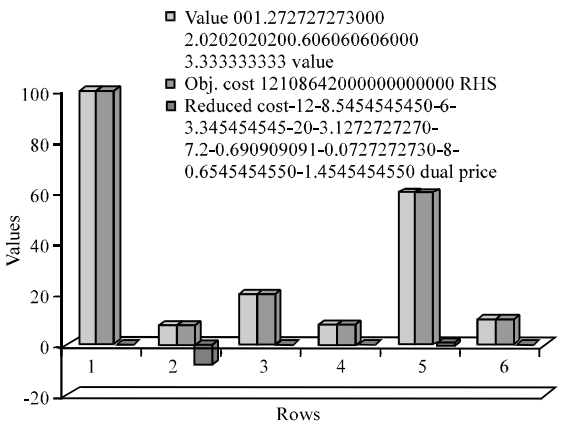

Fig. 1: TOra Software grap

Study of case 1: By assigning the values for P_1-P_6 as 12, 10, 8, 6, 4, 2 and solving through TORA software which is a linear program solver we get the solution as follows (Fig. 1):

$Z_{min} = 10.18$, $x_1 = 2.02$, $x_3 = 0.6061$, $d_1^+ = 11.636$, $d_4^- = 0.6263$, $d_6^- = 3.3333$, $d_2^+ = 1.2727$ and x_2, x_4, x_5, x_6, $d_1^-, d_2^-, d_3^-, d_3^+, d_4^+, d_5^-, d_5^+, d_6^+$ are 0

Since, the value of Z is not equal to zero, the solution satisfies goal 1-5 but fails to satisfy goal 4 (Transportation), goal 6 (General expenses). Since, the optimum is not equal to zero, this indicates that at least one of the goals is not satisfied. Since, $d_2^+ = 1.2727$, sales income target is overachieved by 11.636 lakhs and since, the collection expenses target is also over achieved by 1.2727 units. Since, $d_4^- = 0.6263$ and $d_6^- = 3.3333$, Goal 4 and 6 are underachieved by 0.6263 units and 3.3333 units, respectively. Thus, Goal 1-5 are achieved fully. There is no violation from the desired Goal 1-5. The software called TORA gave the solution after 4 iterations.

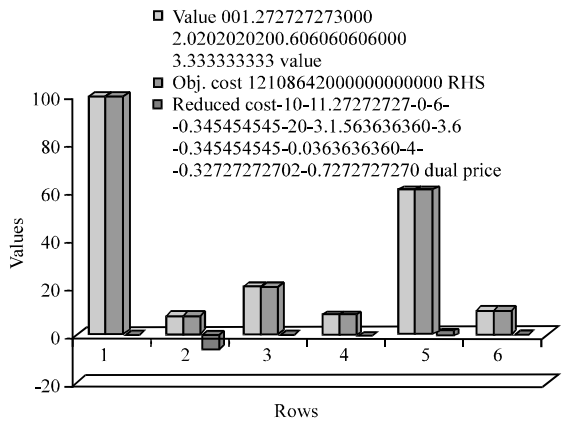

Fig. 2: Graphical interpretation

Study of case 2: By changing the priorities to the goals, we get the different solution. If we assign the priorities for P_1-P_6 as 10, 12, 4, 6, 8, 2 we get following the solution:

$Z_{min} = 5.0909$, $x_1 = 2.0202$, $x_3 = 0.6061$, $d_1^+ = 11.636$, $d_4^- = 0.6263$, $d_6^- = 3.3333$, $d_2^+ = 1.2727$ and $x_2, x_4, x_5, x_6, d_1^-, d_2^-, d_3^-, d_3^+, d_4^+, d_5^-, d_5^+, d_6^+$ are 0

The software called TORA gave the solution after 4 iterations (Fig. 2).

Comparison study of Case 1 and 2: If we compare the above two cases, the 2nd solution is optimal, since, the deviation is a least. This process repeated by changing the priorities and in which case deviation is least, that solution chosen for decision about financial planning. It helps the decision maker to take the decision about the priorities and gives the idea that in which deviation is minimized.

CONCLUSION

Financial planning has important implication on performance of any company. Good financial planning results in profit to the company. In this research, goal programming technique used to lower the deviations in the goals which help in decision-making. Proper and scientific disposal of waste and garbage is also a business which helps in saving the environment and society. Such disposal business will also bring most revenues for the firm if planned properly. On basis of the data collected solution is arrived. Solution is also found by manual calculations. But manual calculation is time-consuming process and not easy. The use of TORA Software helped us to find the solution easily. The study involves considering multiple aims for achieving the profit of the disposal unit using goal programming technique. Goal programming technique gives us the ideal solution under consideration of many goals. Change in priorities will give us different solution. This helps the decision maker to take better decision. This analysis is worthwhile if competing goals involved. The developed model helps in giving the solution for problem containing multiple goals and multiple variables. In all, 18 variables and 6 constraints used in this study.

RECOMMENDATIONS

This study extended to many goals, multiple variables and different targets. Considering that large measure of garbage accumulated in the cities due to massive urbanization and lack of its scientific disposal system causing serious health and environmental concern combined with the lack of knowledge about the uses of wastes, we thought of developing the model for profit generation by using wastes. In this study, an attempt has done for applying goal programming technique in garbage disposal units to derive the desired profit by minimizing deviations in goals. It helps the manager to take better decision in the management sector. It is also hoped that our study may encourage the people to take up the business of sale of wastes by using goal programming tools, attract more and more vendors of recycling units more profit simultaneously. The efforts in generating bi-products from the so-called waste material while give economically, may also indirectly give towards sustainable development. In addition, this will certainly give for creation of better environment for us to live in with lesser garbage thrown around. As a result, the health and hygiene would improve apart from the aesthetics of our neighbouring area, our city, state and the entire nation. This will also urge improvement in the economic development as a better place for living is one of the criteria's for setting up any business unit requiring huge financial investments. Through goal programming technique our study contributes positively for keeping the environment clean and healthy. Thus, the study contributes towards the government's aim of Swatch Bharath.

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