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Design an Optimal System with Fuzzy Multiple Objective De Novo Programming approach

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Abstract:

The De Novo Programming Problem (DNPP) is an extended concept to traditional Multiple Objective Programming (MOP) problem. DNPP was suggested by **Milan Zeleny** (1980). It is robust tools to design a new optimal system that can be minimize or even eliminate the tradeoffs between objectives of the original problem. In real cases, the nature of parameters is ambiguous and not precisely known. In this paper a Fuzzy Multiple objective De Novo Linear Programming (FMODNLP) model is developed to reformulate the MOPP with fuzzy parameters.

Keywords: Fuzzy Multi-objective De Novo Linear programming; Multi-objective programming; De Novo Programming Problem; Optimal System Design; Linear membership function; meta-optimum system; optimal path ratio.

1. Introduction:

In the beginning of 1980's, **Milan Zeleny** introduced de novo programming approach as a robust tool to optimize the MOPP using a new optimal system design in which the available resources in the original problem MOPP converted form constant to be decision variables with the basic decision variable.

The Multiple Objective De Novo Programming Problems (MODNPP) enables us to either minimize or eliminate the conflicting between the objectives function that impossible to satisfy all of them in the same multiple objective programming model. The FMODNLP reformulate the MOPP given the prices of resources and budget respectively. In the realistic situations the parameters of the objectives and constraints are a vague and not precisely known. Due to this the (FMODNLP) model is introduced. After reformulation of (FMODNLP) the Meta Optimum System (MOS) is introduced for searching for a best performance of a given budget. The Optimum Path Ratio (OPR) concept is applied to provide an efficient optimal system. The researches that applied the de novo programming are very rare. **Milan Zeleny (1980)** applied the de novo programming for single objective, **Milan Zeleny (1981**) extended the de novo programming for multiple objectives, **Bare and Mendoza (1988)** applied de novo programming to single and multi-objective forestry land management problems. **Bare and Mendoza (1990)** provides yet another application in the field of forest land management.

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Li and Lee (1990) extended the de novo programming methodology with fuzzy decision theory. A mathematical example was shown which considered all de novo model parameters as fuzzy, **Chen (2006)** considered DNPP as a fuzzy multi stage, **Fiala, Petr (2011)** Applied linear programming approach to solve MODNPP, **Umarusman, N. (2013)** used the min max goal programming to solve the MODNLPP, **and Zhuang, Z. Y., & Hocine, A. (2018)** solved the MODNPP by meta goal programming approach.

This paper is organized as follows: the FMODNLP in section 2, illustrative example is presented in section 3, and finally, section 4 discusses the conclusion.

2. The Fuzzy Multiple Objective De Novo Linear Programming:

In this section, the process of decision making through reformulate an optimal system that better than MOP problem model and then construct MOS are reviewed:

Consider the standard model of MOLP

$$\left.\begin{aligned} &\max z_k = \sum_{j=1}^{n} C_{kj} X_j, && \mathrm{k} = 1,2,\ldots,l, \\ &\text{subject to:} \\ &\sum_{j=1}^{n} a_{ij} X_{j_i} \le b_i, && i = 1,2,\ldots,m, \\ &X_j \ge 0, && j = 1,2,\ldots,n \end{aligned}\right\} \quad (1)$$

Where the parameters b_i represent the given available resources as constant. The efficient solution concept resulting from the solution of MOLP model. To obtain the DNPP formulation we have to change b_i from constants to variables with their values to be determined as follows:

$$\left.\begin{aligned} &\max z_k = \sum_{j=1}^{n} C_{kj} X_j, && \mathrm{k} = 1,2,\ldots,l, \\ &\text{subject to:} \\ &\sum_{j=1}^{n} a_{ij} X_{j_i} - b_i \le 0, && i = 1,2,\ldots,m, \\ &\sum_{j=1}^{m} p_i b_i \le B, \\ &X_j \ge 0, && j = 1,2,\ldots,n \end{aligned}\right\} \quad (2)$$

Where $X_j . b_i$ are decision variables for products and available resources respectively, p_i, B are the given of both the unit price of resource i and total available budget respectively.

2.1 FMODNLP:

The parameters of the optimization model are usually vague and uncertain. Zimmermann (1978) used Bellman and Zadeh (1970) to reformulate Linear Programming Problem (LPP) with fuzzy goals and constraints respectively thus can be solved as a conventional LPP.

A FMODNLP problem can be reformulated as a conventional LPP as:

$$
\left.
\begin{array}{ll}
\max \tilde{z}_k = \sum_{j=1}^{n} \tilde{C}_{kj} X_j, & K = 1,2,\ldots,l, \\
\text{subject to:} & \\
\sum_{j=1}^{n} a_{ij} X_j - b_i \le 0, & i = 1,2,\ldots,m, \\
\sum_{j=1}^{m} \tilde{p}_i b_i \le \tilde{B}, & \\
X_j \ge 0, & j = 1,2,\ldots,n
\end{array}
\right\} \quad (3.a)
$$

Where $\tilde{C}_{kj}, \tilde{p}_i, \tilde{B}$ are fuzzy values.

The preceding model can be reformulated by defining unit cost $v_j = p_i b_i$ as follows:

$$
\left.
\begin{array}{ll}
\max \tilde{z}_k = \sum_{j=1}^{n} \tilde{C}_{kj} X_j, & K = 1,2,\ldots,l, \\
\text{subject to:} & \\
\sum_{j=1}^{n} \tilde{v}_i \tilde{x}_i \le \tilde{B}, & i = 1,2,\ldots,m, \\
X_j \ge 0, & j = 1,2,\ldots,n
\end{array}
\right\} \quad (3.b)
$$

According to Zimmermann (1978), the optimization system is formulated by solving each objective individually to obtain $z_k^L = \min z_k$, s.t. $x_i \in X =$ and $z_k^u = \max z_k$, s.t. $x_i \in X$

The linear membership function for fuzzy objectives is considered as follows:
$\forall \, \mathrm{k} = 1,2,\ldots,l$:

$$
\mu_{z_k}(x) = \begin{cases} 0 & z_k \le z_k^L \\ \dfrac{z_k - z_k^L}{z_k^U - z_k^L} & z_l \le z_k \le z_u \\ 1 & z_k \succ z_k^U \end{cases} \quad (4)
$$

The linear membership functions for fuzzy maximization and minimization constraints are considered as follows:

$$
\mu_{g_i(x)} = \begin{cases} 0 & \forall g_i(x) \ge b_i + d_i \\ 1 - \frac{g_i(x) - b_i}{d_i} & \forall \, b_i \le g_i(x) \le b_i + d_i \\ 1 & \forall g_i(x) \le b_i \end{cases} \quad (5)
$$

After constructing the membership function defined in (4) and (5), the compromise solution is obtained from intersection between both fuzzy objectives and constraints respectively.so that to obtain compromise solution Zimmerman (1978) suggested the following model that equivalent to fuzzy model as:

$$
\left.\begin{aligned}
&\max \lambda \\
&\text{subject to:} \\
&\lambda \le \Big(\sum_{k=1}^{l} C_{kj} X_j - z_k^L\Big) / (z_k^U - z_k^L), \qquad k = 1,2,...,l, \\
&\lambda \le \Big(\sum_{i=1}^{m} g_i(x) - b_i\Big) / d_i \\
&\sum_{j=1}^{n} A_j X_j \le B \qquad j = 1,2,....,n \\
&\lambda \in [0,1], X_j \ge 0.
\end{aligned}\right\} \qquad (6)
$$

The solution resulting from the last model contributes in formulating the MOS as:

$$
\left.\begin{aligned}
&\min z = \sum_{j=1}^{n} v x_i, \\
&\text{subject to:} \\
&C_{kj} X_j \ge z_k^*, \qquad K = 1,2,...,l \\
&X_j \ge 0, \qquad j = 1,2,...,n
\end{aligned}\right\} \qquad (7)
$$

According to Fiala, P. (2011) the solution of MOS model provides solution as:

$$x^*, B^* = vx^*, b^* = a_{ij} x^*. \qquad (8)$$

A minimal budget to accomplish z^* through x^* and b^* is identified by B^* value.

The OPR to accomplish the best performance for a given budget is considered as:

$$r = \frac{B}{B^*}. \qquad (9)$$

Fiala, P. (2011) mention that the OPR is fast and robust tool for redesigning an efficient optimal large- scale systems. The OPR for B

$$x = rx^*, b = rb^*, z = rz^*. \qquad (10)$$

2.2 The computational of Solution procedure to the proposed approach:

Step 1: Formulate the FMODNLP problem**.**

Step 2: Solving each objective function individually subject to given constraints of system.

Step 3: Use step2 to determine the lower and upper bound respectively for each objective.

Step 4: Based on step 3, construct the membership function for goals and constraints respectively.

Step 5: Formulate the problem (6).

Step 6: From step 5, the resulting solution is used to formulate the MOS and hence the OPR.

3. Illustrative example:

To test the FMODNLP, the same example of Zeleny, M. (1986) has been used with fuzzy parameters.

$$\text{Max}\, Z = \tilde{50}x_1 + \tilde{100}x_2 + \tilde{17}.5x_3$$
$$\text{Max}\, Z_2 = \tilde{92}x_1 + \tilde{75}x_2 + \tilde{50}x_3$$
$$\text{Max}\, Z_3 = \tilde{25}x_1 + \tilde{100}x_2 + \tilde{75}x_3$$

s.t.

$$12x_1 + 17x_2 \le b_1,$$
$$3x_1 + 9x_2 + 8x_3 \le b_2,$$
$$10x_1 + 13x_2 + 15x_3 \le b_3,$$
$$6x_1 + 16x_3 \le b_4,$$
$$12x_2 + 7x_3 \le b_5,$$
$$9.5x_1 + 9.5x_2 + 4x_3 \le b_6,$$
$$0.\tilde{75}\, b_1 + 0.\tilde{60}\, b_2 + 0.\tilde{35}\, b_3 + 0.\tilde{50}\, b_4 + 1.\tilde{1}5\, b_5 + 0.\tilde{65}\, b_6 = 46\tilde{5}8.75,$$
$$x_1, x_2 \text{ and } x_3 \ge 0.$$

According to (3.b) the model can be rewrite as:

$$\text{Max}\, Z = \tilde{50}x_1 + \tilde{100}x_2 + \tilde{17}.5x_3$$
$$\text{Max}\, Z_2 = \tilde{92}x_1 + \tilde{75}x_2 + \tilde{50}x_3$$
$$\text{Max}\, Z_3 = \tilde{25}x_1 + \tilde{100}x_2 + \tilde{75}x_3$$

s.t.

$$23.475x_1 + 42.675x_2 + 28.7x_3 = 4658.75$$
$$x_1, x_2 \text{ and } x_3 \ge 0.$$

Steps 2 and 3: Finding the upper and lower bound by solving each objective as a single and construct the payoff table:

	Z_1	Z_2	Z_3	X_1	X_2	X_3
Max Z_1	10916.81	8187.61	10916.81	0	109.1681	0
Max Z_2	9922.79	18257.93	4961.395	198.4558	0	0
Max Z_3	2840.702	8116.29	12174.43	0	0	162.3258

$$2840.702 < z_1 < 10916.81,$$
$$8116.29 < z_2 < 18257.93,$$
$$\text{and} \quad 12174.43 < z_3 < 4961.395.$$

Step 4: Construct the membership function for all fuzzy goals and fuzzy constraints:

$$\mu_{Z_1}(x) = \frac{(50x_1 + 100x_2 + 17.5x_3) - 2840.702}{10916.81 - 2840.702}$$

$$\mu_{Z_2}(x) = \frac{(92x_1 + 75x_2 + 50x_3) - 8116.29}{18257.9 - 8116.29}$$

$$\mu_{Z_2}(x) = \frac{(25x_1 + 100x_2 + 75x_3) - 4961.395}{12174.43 - 4961.395}$$

$$\mu g_i(x) = \frac{(23.475x_1 + 42.675x_2 + 28.7x_3) - 4000}{4658.75 - 4000}$$

$$\mu g_i(x) = \frac{7000 - (23.475x_1 + 42.675x_2 + 28.7x_3)}{7000 - 4658.75}$$

Step 5: Formulate the equivalent crisp formulation of the fuzzy optimization problem as:

$$\max \quad \lambda$$

subject to

$$\frac{(50x_1 + 100x_2 + 17.5x_3) - 2840.702}{10916.81 - 2840.702} \ge \lambda,$$

$$\frac{(92x_1 + 75x_2 + 50x_3) - 8116.29}{18257.9 - 8116.29} \ge \lambda,$$

$$\frac{(25x_1 + 100x_2 + 75x_3) - 4961.395}{12174.43 - 4961.395} \ge \lambda,$$

$$\frac{(23.475x_1 + 42.675x_2 + 28.7x_3) - 4000}{4658.75 - 4000} \ge \lambda,$$

$$\frac{7000 - (23.475x_1 + 42.675x_2 + 28.7x_3)}{7000 - 4658.75} \ge \lambda$$

$$x_1, x_2, \text{and } x_3 \ge 0, \qquad b_1, b_2, b_3, b_4, b_5, \text{and } b_6 \ge 0, \qquad \lambda = [0,1],$$

Step 6: Lingo software program has been used to solve the preceding crisp model, the solution obtained as: $\lambda = 0.69$, $x_1^* = 110.63, x_2^* = 15.35$ and $x_3^* = 74.7$,

$b_1^* = 1588.52, b_2^* = 1067.631, b_3^* = 72426.362, b_4^* = 1859.006, b_5^* = 707.0706, \text{and } b_6^* = 1495.628$.

From this result the optimal system performance is

$z_1^* = 8373.72$, $z_2^* = 15064.42$ and $z_3^* = 9903.11$.

Use the values of z_k^* in order to formulate the MOS as:

$$\text{Max } Z = 23.475x_1 + 42.675x_2 + 28.7x_3$$
$$s.t$$
$$50x_1 + 100x_2 + 17.5x_3 \geq 8387.719$$
$$92x_1 + 75x_2 + 50x_3 \geq 15064.422$$
$$25x_1 + 100x_2 + 75x_3 \geq 9903.113$$
$$x_i \geq 0,$$

The solution of the MOS is:

$$B^* = vx^* = 5395.987$$

From (9) the OPR = $\frac{4658.75}{5395.987} = 0.86$

From (10) the optimal system of given budget B is designed as:

$$x_1 = 95.52, x_2 = 13.25, \text{ and } x_3 = 64.5,$$
$$b_1 = 1371.5, b_2 = 921.77, b_3 = 2094.86, b_4 = 1605, b_5 = 610.5, \text{ and } b_6 = 1291.28,$$
$$z_1 = 7229.64, z_2 = 13006.22, \text{ and } z_3 = 8550$$

The preceding results of the proposed FMODNLP approach show that the level of objectives satisfactions is increased from Li, R. J., & Lee, E. S. (1990) $\lambda = 0.56$ to $\lambda = 0.69$.

The proposed approach applied the MOS and OPR concepts to design a new and efficient optimal system.

4. Conclusion:

In this paper, the de novo programming is considered with fuzzy parameters, the advantages of this approach is to enable the decision makers (DMs) to deal with the lake of information and imprecision data in the parameters. The proposed approach is more flexible and applicable for the de novo programming problem with fuzzy parameters. The FMODNLP applied the linear membership function to obtain a set of efficient solution allowed to the DMs. The concepts of MOS and OPR applied to develop a new and efficient large-scale linear model.

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Solving Production Problem with Fuzzy Multi-Objective Using Goal Programming

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Abstract

In industrial field, the multi-objective optimization problem includes variety of challenges. It is observed that there is a lack of precise information in various parameters that need utmost attention. In the real world, production planning model contains a fuzzy coefficients which could be solved using modified S-curve.

In this paper, the modified Chocoman model is presented. The new model of multi-objectives contains fuzzy coefficients in two objectives (revenue and profit). First, the fuzzy multi-objectives model is transformed to crisp using the modified S-curve membership function. Then, the goal programming is introduced by adding deviational variables to be new goals to minimize deviations in goals. By the end of this paper, we succeed reaching to best compromise of decision variables in goals.

Keywords: modified Chocoman model, fuzzy multi-objectives model, modified S-curve membership function, goal programming

1. Introduction

The modern trend in industrial application problem deserves modeling of all relevant or fuzzy information involved in a real decision making problem. S-curve membership function, referred as the non-linear membership function has been used in problems involving fuzzy coefficients. For the problem in this paper, a modified S-curve membership function (P. vasant, 2005) is applied to solve the first part of the problem which assimilates in the fuzzy coefficients in the objective functions. Either regarding the second part of the problem assimilates in solving multi-objective industrial production planning problem by using goal programming with deviational variables. Prior research works in the field of fuzzy linear programming with fuzzy objective function coefficients are enormous.

Literature contains several works from (pandian, M.V., et al., 2002), (pandian vasant, et al., 2005), (pandian, M. 2006), (sani susanto, et al., 2006), (pandian, M. vasant, et al., 2006), (sani susanto, et al., 2006) and many others.

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In this paper, the fuzzy linear programming with fuzzy objective function coefficients is solved using modified S-curve membership function. Then, the goal programming with deviational variables is applied. We modified the model of chocoman company USA. The data for this problem has been adopted from the data-bank of chocolate Inc., USA (sani susanto, et al., 2006), (alaa sheta, et al., 2012).

In part two, the goal programming is applied on modified chocoman problem; adding deviational variables to objective functions hoping to minimize deviations in goals. As an analyst, we seek the best methodologies for the decision makers with fuzzy objective coefficient and maximizing five objective functions in order to identify a final decision to satisfy a decision maker's goals.

The main objective of this paper is to solve the modified well-known chocolate industrial problem using fuzzy linear programming and goal programming algorithms.

This paper is organized as follows: Section 2 presents "Fuzzy linear programming" which particular case of the logistic function and Membership function in coefficient of the objective function and this section includes sub-sections 2.1 "Modified S-Curve Membership Function" & Section 2.2 "The membership function of fuzzy coefficients in objective function $\tilde{C}(j)$". Section 3 considers "goal programming". Section 4 presents "Problem definition". Section 5, shows "Solving the modified Chocoman problem" and finally Section 6 presents "Conclusion".

2. Fuzzy Linear Programming

The methodology of fuzzy linear programming has references to various works by (zimmermann, HJ, 1976), (verdegay, JL, 1982), (chanas, S, 1983), (carlsson, C and korhonen, P, 1986) and (werners, B., 1987). The fuzzy linear programming FLP is based on the interactive with decision maker in order to find a compromised satisfactory solution for the FLP problem. In fuzzy model, the objective function coefficients may be fuzzy, instead of being precise numbers as in a crisp model. For example, revenue, profit, cost and so on in a production planning center are always imprecise because of incomplete information and uncertainty in various potential suppliers and environments. Therefore, the fuzzy objective coefficients are considered in this paper.

2.1 Modified S-Curve Membership Function

The modified S-curve membership function is a particular case of the logistic function with specific values of B, C and α. These values are to be found.

$$\mu(x) = \begin{cases} 1 & x < x^a \\ 0.999 & x = x^a \\ \frac{B}{1+Ce^{\alpha x}} & x^a < x < x^b \\ 0.001 & x = x^b \\ 0 & x > x^b \end{cases} \qquad (1)$$

where μ is the degree of membership function

As shown in function (1), the S-curve, is the membership function and it is defined as $0.001 \leq \mu(x) \leq 0.999$. This range is selected because in manufacturing systems the work force need not always be 100% of the requirement. At the same time, the work force will not be 0%. Therefore, there is a range between x^a and x^b with $0.001 \leq \mu(x) \leq 0.999$.This concept of range of $\mu(x)$ is used in an illustrative example (pandian, MV, 2002) and (pandian, MV, et al., 2002).

We rescale the x-axis as $x^a = 0$ and $x^b = 1$ in order to find the values of B, C and α. (Nowakowska, N, 1977) has performed such a rescaling in his work in social sciences. The values for C = 0:001001001, B=1 and a=13.81350956.

This logistic function is given by the following equation (3) (Goguen, JA, 1969), (Zadeh, LA, 1971), (Zadeh, LA, 1975) & (vasant, p., 2003) as follows:

2.2 The Membership Function Of Fuzzy Coefficients In Objective Function $\tilde{C}(j)$

The membership function of $\tilde{C}(j)$ is defined as follows:

$$\mu(c_j) = \begin{cases} 1 & c_j < {c_j}^a \\ 0.999 & c_j = {c_j}^a \\ \frac{B}{1+Ce^{\alpha(c_j - {c_j}^a / {c_j}^b - {c_j}^a)}} & {c_j}^a < c_j < {c_j}^b \\ 0.001 & c_j = {c_j}^b \\ 0.000 & c_j > {c_j}^b \end{cases} \qquad (2)$$

Where $\mu(c_j)$ is the membership function of c_j and ${c_j}^a$ and ${c_j}^b$ are the lower and the upper boundary of the fuzzy coefficient of $\tilde{C}(j)$, respectively. The number $\mu(c_j)$ = 1 and $\mu(c_j)$ = 0 corresponds to the 'crisp' values. ${c_j}^a < \tilde{C}(j) < {c_j}^b$ is the fuzzy region.

The membership function of fuzzy coefficient in objective function $\tilde{C}(j)$ is given as:

$$\mu_{c_j} = \frac{B}{1+Ce^{\alpha(c_j - {c_j}^a / {c_j}^b - {c_j}^a)}} \qquad (3)$$

By rearranging exponential term & taking $\log_e$ both sides Hence reaching to

$$c_j = c_j{}^a + \left(\frac{c_j{}^b - c_j{}^a}{\alpha}\right) \ln \frac{1}{C} \left(\frac{B}{\mu_{c_j}} - 1\right) \qquad (4)$$

Since c_j is a fuzzy coefficient in the objective function as in Equation (5), it is denoted as $\tilde{C}(j)$.

$$\tilde{C}(j) = c_j{}^a + \left(\frac{c_j{}^b - c_j{}^a}{\alpha}\right) \ln \frac{1}{C} \left(\frac{B}{\mu_{c_j}} - 1\right) \qquad (5)$$

The membership function for μ_{c_j} and the fuzzy interval, $c_j{}^a$ to $c_j{}^b$, for $\tilde{C}(j)$

3. Goal Programming

Goal Programming (GP) is a multi-criteria decision making technique (charnes, 1955) and (charnes and cooper, 1961). It is traditionally seen as an extension of linear programming to include multiple objectives, expressed by means of the attempted achievement of goal target values for each objective.

Another way of viewing the relationship is that linear programming can be considered to be a special case of goal programming with a single objective. All of these considerations place goal programming within the paradigm of multiple objective programming.

GP is now an important area of multi-criteria optimization. The idea of goal programming is to establish a achieve level of achievement for each criterion. GP is ideal for criteria with respect to which target (threshold) values of achievement are of significance. Goal programming is distinguished from linear programming by:

- The conceptualization of objectives as goals.
- The assignment of priorities and/or weights to the achievement of the goals.
- The presence of deviational variables $d_i^+ \; and \; d_i^-$ to measure overachievement and underachievement from target (threshold) levels t_i.
- The minimization of weights sum of deviational variables to find solution that best satisfy the goals.

4. Problem Definition

The firm chocoman, Inc. (sani susanto, et al., 2006) manufactures 8 different kinds of chocolate products. There are 8 raw materials to be mixed in different proportions and 9 processes (facilities) to be utilized having limitations resources of raw materials. The problem can be presented as multi-objective functions (alaa sheta, et al., 2012) with two of those functions have fuzzy objectives in coefficients and 8 parameters to be optimized and 29 non-fuzzy constraints that should be satisfied by the end of the solution processes.

The decision variables for the chocolate problem are defined as:
X_1 = milk chocolate of 250g to be produced
X_2 = milk chocolate of 100g to be produced
X_3 = crunchy chocolate of 250g to be produced
X_4 = crunchy chocolate of 100g to be produced
X_5 = chocolate with nuts of 250g to be produced
X_6 = chocolate with nuts of 100g to be produced
X_7 = chocolate candy to be produced
X_8 = chocolate wafer to be produced

Here, we consider the problem of chocolate production planning in which the two of objectives function coefficients are fuzzy. The fuzzy linear multi-objective programming model for this problem is as follows:

$$F_1: maximize\ z_1 = \sum_{j=1}^{8} \tilde{C}(j) X_j$$

$$F_2: maximize\ z_2 = \sum_{j=1}^{8} \tilde{C}(j) X_j$$

$$F_3: maximize\ z_3 = \sum_{j=1}^{6} C(j) X_j$$

$$F_4: maximize\ z_4 = \sum_{j=1}^{8} C(j) X_j$$

$$F_5: maximize\ z_5 = \sum_{j=1}^{8} C(j) X_j \qquad (6)$$

$$s.t \quad \sum_{i=1}^{29} \sum_{j=1}^{8} a_{ij} X_j \le b_i$$

where a_{ij} and b_i are non-fuzzy parameters, and $\tilde{C}(j)$ of F_1 & F_2 are fuzzy parameters, $c(j)$ of F_3, F_4 & F_5 are non-fuzzy parameters, $c(j), X_j \ge 0, j = 1,2,\ldots,8$.

The following objective functions and constraints are established by the production planning department of chocoman Inc. We add new objective with fuzzy values thus, the modified Chocoman problem is shown as follows:

(Maximization – five objective functions)

F_1: Revenue

[281,469]x_1+[112,188]x_2+[301,499]x_3+[120,200]x_4+[313,523]x_5+[130,218]x_6+ [300,502]x_7+[112,188]x_8

F_2: profit

$$[135,225]x_1+[62,104]x_2+[115,191]x_3+[54,90]x_4+[97,162]x_5+[52,87]x_6+[156,261]x_7+[62,104]x_8$$

F_3: market share for chocolate bars

$$0.25x_1+0.1x_2+0.25x_3+0.1x_4+0.25x_5+0.1x_6$$

F_4: units produced

$$F_4= x_1+x_2+x_3+x_4+x_5+x_6+x_7+x_8$$

F_5: plant utilization

$$1.65x_1+0.9x_2+1.975x_3+1.03x_4+1.75x_5+0.94x_6+4.2x_7+1.006x_8$$

Subject to

$$X_1-0.6x_2 \leq 0$$

$$X_3-0.6x_4 \leq 0$$

$$X_5-0.6x_6 \leq 0$$

$$-56.25x_1-22.5x_2-60x_3-24x_4-63x_5-26.25x_6+400x_7+150x_8 \leq 0$$

(Cocoa usage)

$$87.5x_1+35x_2+75x_3+30x_4+50x_5+20x_6+70x_7+12x_8 \leq 100000$$

(Milk usage)

$$62.5x_1+25x_2+50x_3+20x_4+50x_5+20x_6+30x_7+12x_8 \leq 120000$$

(Nuts usage)

$$0x_1+0x_2+37.5x_3+15x_4+75x_5+30x_6+0x_7+0x_8 \leq 60000$$

(Confectionary sugar usage)

$$100x_1+40x_2+87.5x_3+35x_4+75x_5+30x_6+210x_7+24x_8 \leq 200000$$

(Flour usage)

$$0x_1+0x_2+0x_3+0x_4+0x_5+0x_6+0x_7+72x_8 \leq 200000$$

(Aluminum foils usage)

$$500x_1+0x_2+500x_3+0x_4+0x_5+0x_6+0x_7+250x_8 \leq 500000$$

(Paper usage)

$$450x_1+0x_2+450x_3+0x_4+450x_5+0x_6+0x_7+0x_8 \leq 500000$$

(Plastic usage)

$$60x_1+120x_2+60x_3+120x_4+60x_5+120x_6+1600x_7+250x_8 \leq 500000$$

(Cooking facility usage)

$$0.5x_1+0.2x_2+0.425x_3+0.17x_4+0.35x_5+0.14x_6+0.6x_7+0.096x_8 \leq 1000$$

(Mixing facility usage)

$$0x_1+0x_2+0.15x_3+0.06x_4+0.25x_5+0.1x_6+0x_7+0x_8 \leq 200$$

(Forming facility usage)

$$0.75x_1+0.3x_2+0.75x_3+0.3x_4+0.75x_5+0.3x_6+0.9x_7+0.36x_8 \leq 1500$$

(Grinding facility usage)

$$0x_1+0x_2+0.25x_3+0x_4+0x_5+0x_6+0x_7+0x_8 \leq 200$$

(Wafer making facility usage)

$$0x_1+0x_2+0x_3+0x_4+0x_5+0x_6+0x_7+0.3x_8 \leq 100$$

(Cutting facility usage)

$$0.5x_1+0.1x_2+0.1x_3+0.1x_4+0.1x_5+0.1x_6+0.2x_7+0x_8 \leq 400$$

(Packaging facility usage)

$$0.25x_1+0x_2+0.25x_3+0x_4+0.25x_5+0x_6+0x_7+0.1x_8 \leq 400$$

(Packaging 2 facility usage)

$$0.05x_1+0.3x_2+0.05x_3+0.3x_4+0.05x_5+0.3x_6+2.5x_7+0.15x_8 \leq 1000$$

(Labor usage)

$$0.3x_1+0.3x_2+0.05x_3+0.3x_4+0.3x_5+0.3x_6+2.5x_7+0.25x_8 \leq 1000$$

(Demand for MC 250)

$$X_1 \leq 500$$

(Demand for MC 100)

$$X_2 \leq 800$$

(Demand for CC 250)

$$X_3 \leq 400$$

(Demand for CC 100)

$$X_4 \leq 600$$

(Demand for CN 250)

$$X_5 \leq 300$$

(Demand for CN 100)

$$X_6 \leq 500$$

(Demand for candy)

$$X_7 \leq 200$$

(Demand for wafer)

$$X_8 \leq 400$$

The decision variables $X_{1\,\ldots}\,X_8$, $X_{1\,\ldots}\,X_8 \geq 0$.

The revenue and the profit objective functions coefficients are fuzzy parameters.

The Steps of Solving The Modified Chocoman Problem Are as Follows:

Step 1: **T**ransform fuzzy parameters in objective functions to crisp parameters according to **equation (7).**

Step 2: Determine the lower and upper bound for each objective by solving each problem individually as a single objective using package.

Step 3: Use the upper bounds only (if the problem is maximization for all objectives). Then, these upper bound are put them as goals in the R.H.S (b_i) of goal programming model to minimize the deviational variables ($\boldsymbol{d_i^-}$) if the objectives max and ($\boldsymbol{d_i^+}$) if the objectives mini).

Step 4: Solve the final crisp model applying goal programming approach with equal weights using the package reaching to the final optimal **decision variables of $\mathbf{x_i^*}$**

5. Solving The Modified Chocoman Problem

This section discusses the results of modified S-Curve membership function of fuzzy multi-objectives linear programming and then, adding deviational variables of goal programming. Those methods are used for solving the modified Chocoman problem which represents as industrial production planning problem.

After applying **equation (7)** as we illustrated in **(step 1)** to transform fuzzy coefficients in revenue and profit of objective functions to crisp parameters; the model become as follows:

F_1: Revenue

$$313x_1+125x_2+334x_3+133x_4+348x_5+145x_6+334x_7+125x_8$$

F_2: profit

$$150x_1+69x_2+128x_3+60x_4+108x_5+58x_6+174x_7+69x_8$$

F_3: market share for chocolate bars

$$0.25x_1+0.1x_2+0.25x_3+0.1x_4+0.25x_5+0.1x_6$$

F_4: units produced

$$x_1+x_2+x_3+x_4+x_5+x_6+x_7+x_8$$

F_5: plant utilization

$$1.65x_1+0.9x_2+1.975x_3+1.03x_4+1.75x_5+0.94x_6+4.2x_7+1.006x_8$$

Subject to

$$s.t \quad \sum_{i=1}^{29}\sum_{j=1}^{8} a_{ij}X_j \le b_i$$

Then, this above model became typical multi-objective linear programming

Table 5.1 The maximum and minimum values of objective functions

Objective function	F_i^{min}	F_i^{max}
F_1	0	508429
F_2	0	220748
F_3	0	357
F_4	0	2826
F_5	0	3519

Table 5.1 illustrates **(as shown before in step 2)** the maximum and minimum values of each objective function to transform them as illustrated in **(step 3)** reaching to the goal programming model with assumption that all objective functions have equal weights. Thus, the goal programming model is as follows:

$$\text{minimize}\, G = d_1^- + d_2^- + d_3^- + d_4^- + d_5^-$$

Subject to

$$F_1 - d_1^+ + d_1^- = 508429 \quad (F_1^{max})$$
$$F_2 - d_2^+ + d_2^- = 220748 \quad (F_2^{max})$$
$$F_3 - d_3^+ + d_3^- = 357 \quad (F_3^{max})$$

$$F_4 - d_4^+ + d_4^- = 2826 \qquad (\boldsymbol{F_4^{max}})$$
$$F_5 - d_5^+ + d_5^- = 3519 \qquad (\boldsymbol{F_5^{max}})$$
$$s.t \qquad \sum_{i=1}^{29}\sum_{j=1}^{8} a_{ij}X_j \le b_i$$

Where $d_1^+, d_1^-, d_2^+, d_2^-, d_3^+, d_3^-, d_4^+, d_4^-, d_5^+, d_5^-$ are deviational variables and must be nonnegative & F_1, F_2, F_3, F_4, F_5 are objective functions, where $X_j \ge 0$.

As shown in **(step 4),** applying WINQSB program (goal programming tool); reaching to the optimal solution as follows:

Table 5.2 The optimal solution of the Chocoman problem

Objective function	Solution values
F_1 (revenue)	508424
F_2 (profit)	215516
F_3 (market share chocolate bars)	329
F_4 (units produced)	1477
F_5 (plant utilization)	3376
Decision variables	**Solution values**
X_1	188
X_2	316
X_3	300
X_4	500
X_5	300
X_6	500
X_7	95
X_8	278

In Table 5.2, the optimal solution of the chocoman problem is obtained and measured. The total revenue (F_1) is **equal to 508424** and this value is almost **100%** of goal No. 1 (F_1^{max}). The total profit (F_2) is **equal to 215516** and this value represents **97.6 %** of goal No. 2 (F_2^{max}).

The goal No. 3 of market share chocolate bars (F_3) is **equal to 329** and this value represents **92 %** of goal of No. 3 (F_3^{max}). The units produced (F_4) is **equal to 2477** and this value is **88 %** of goal of No. 4 (F_4^{max}) and finally, the goal of plant utilization (F_5) is equal to **3376** and this value represents **96 %** of goal No. 5 (F_5^{max}).

6. Conclusion

In this paper, we have a solution to the industrial production planning problem using fuzzy multi-objectives and goal programming approaches in modified Chocoman problem. The modified S-Curve membership function is used to transform fuzzy parameters in coefficients of objective functions to crisp. Then, the new formulation model is found suitable to apply the goal programming approach. This sequence as a methodology to solve the modified Chocoman problem has applied successfully and the comparison with upper boundaries of objective functions appeared satisfactory results.

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Asset Allocation Management to Secure Pension Fund in Fuzzy Environment

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Abstract

Pension fund needs to produce a high-income return correspond to actuarial expectations of different kinds of benefits. An asset allocation management (ALM) model of a pension fund must consider a large planning horizon because of its long-term obligations. ALM controls solvency of the fund by suitable investments and contribution policies to secure the pensioners future liabilities. Financial markets have fuzziness, vagueness and ambiguity variables. Fuzzy numbers given by experts and accepted by decision-makers, provide a powerful tool for describing the fuzzy uncertainty. In this paper, a portfolio optimization model is introduced based on fuzzy variance minimization at a required return level that secures the fund against insolvency risk. This method uses a fuzzy approach to the mean-variance defined by Markowitz so that future returns of the stocks are predicted with help of Triangular Fuzzy Numbers (TFN).

Keywords:

Pension fund; Fuzzy sets; Fuzzy mean and variance; Insolvency risk.

1. Introduction

Pension fund must be periodic evaluated by actuaries and predict annual cash flow of income and liabilities (outcomes). The sponsor of plan take decisions at certain time, as investment decision to decide which assets allocated to attain a return enough to pay the participants' liabilities. The paper proposes model to assistance the decision maker to take this decision. Depending on earlier works of Markowitz (1952), Dubois and Prade (1987), fuzzy approach Carlsson and Fullër (2001) defined possibilistic mean value, variance and covariance of fuzzy numbers. The paper proposes modify Markowitz model by adding new constraint that responsible for secure the pension fund towards insolvency risk.

Pension funds are becoming fundamental tools in financial markets. Nowadays, pension fund investments represent a considerable percentage of financial market operations. In a general perspective, there are two extremely different ways to manage a pension fund. First, the pension fund can be managed through Defined Benefit (DB) plans, where benefits are fixed in advance by the sponsor and contributions are initially set and subsequently adjusted in order to maintain the fund in balance.

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In other words, DB plan provides a guarantee by the pension plan or government that a pension will be paid based on a certain formula in which contribution may not be tied actually to benefits. Secondly, pension fund can be managed through Defined Contribution (DC) plans, where contributions are fixed and benefits depend on the returns on fund portfolio. In other words, DC plan provides a pension plan in which a periodic contribution is prescribed and the benefit depends on the contribution plus the investment return.

Many papers used the types of pension plans as Boulier et al. (2001), Vigna and Haberman (2001), Haberman and Vigna (2002), Deelstra et al. (2000,2003), Battocchio and Menoncin (2002), call in DC pension funds, Haberman and Sung (1994), Chang (1999), Haberman et al. (2000), Taylor (2002), Chang et al. (2003) and Josa-Fombellida and Rincón-Zapatero (2001,2004), in DB pension funds, and Cairns (2000), in both types of plans. Yufei et al. (2016) they consider the portfolio optimization problem for a pension fund consisting of various government and corporate bonds. And aims maximize the fund's cash position at the end of the time horizon, while allowing for the possibility of bond defaults.

The literature about portfolio selection and pension funding, such as those of Chang (1999), Cairns (2000), Boulier et al. (2001), Josa-Fombellida and Rinc´on Zapatero (2001, 2004, 2006, 2008, 2012, 2017), Chang et al. (2003), Deelstra et al. (2003), Battocchio and Menoncin (2004), Cairns et al. (2006), Xu et al (2007), Delong et al. (2008) and Le Cortois and Menoncin (2015) All previous papers assume that uncertainty variables are geometric Brownian motions. This assumption does not reflect the sometimes observed real financial phenomena.

Josa-Fombellida and Rinc´on-Zapatero (2017) present a differential game between the sponsoring firm and workers' representatives (the union) is studied the objective of the union to maximize the expected discounted utility of the extra benefits claimed on the fund surplus, whereas the firm's objective is to maximize the expected discounted utility of the fund surplus. Zhao and Rong (2017) maximize a power utility function in a portfolio selection problem. Josa-Fombellida and Rinc´on-Zapatero (2018), study the optimal asset allocation problem of a DB pension plan that operates in a financial market composed of risky assets whose prices are constant elasticity variance processes (CEV).

Markowitz specified the trade-off facing the investor: risk versus expected return. The investment decisions are not simply which securities to own, but how to divide the investor's wealth amongst them. This is problem called "Portfolio Selection" hence the title of Markowitz's seminal article published in the 1952 issue of the Journal of Finance. He identifies all feasible portfolios that minimize risk (as measured by variance or standard deviation) for a certain level of expected return and maximize expected return for a certain level of risk.

In fuzzy environment this article modifies Markowitz's model by adding new constraint that responsible for secure the pension fund against insolvency risk i.e. ability for cover all participant's liabilities along horizon where the return is TFN.

This paper is organized as follows. In Section 2, shows important definitions are useful for the problem. In section 3, shows proposed model for the problem. In section 4, numerical example to illustrate the proposed model. And finally, Section 6 presents a conclusion.

2. Definitions

Definition 1 (Carlsson and Fuller, 2001) A fuzzy number A is a fuzzy set of the real line R with a normal fuzzy convex and continuous membership function of bounded support. The family of fuzzy numbers will be denoted by F. A γ-level set of a fuzzy number A is defined by $[A]^{\gamma} = \{t \in R \mid A(t) \geq \gamma\}$ if $\gamma > 0$ and $[A]^{\gamma} = cl\{t \in R \mid A(t) > 0\}$ (the closure of the support of A) if $\gamma = 0$. It is well known that if A is a fuzzy number then $[A]^{\gamma}$ is a compact subset of R for all $\gamma \in [0; 1]$.
A fuzzy number A is called a triangular fuzzy number (TFN) with peak (or center) r, left width b > 0 and right width c > 0 if its membership function has the following form:

$$\mu(x) = \begin{cases} \dfrac{b + x - r}{b}, & r - b \leq x < r \\ \dfrac{c - x + r}{c}, & r \leq x < r + c \\ 0 \quad, & \text{otherwise} \end{cases}$$

We use notation A = (r, b, c), the support of a TFN A is (r - b, r + c) with center r can be considered as "x is approximately equal to r".
If b = c then we call TFN symmetrical, and refer to it as (r, b).
Let A = (a, α) and B = (b, β) be two symmetrical TFNs. Then

$$A + B = (a + b, \alpha + \beta); \qquad \lambda A = (\lambda a, |\lambda|\alpha)$$

Let apply to a TFN R= (r, b, c) with center r, left width b>0 and right width c > 0 as depicted in Fig.1

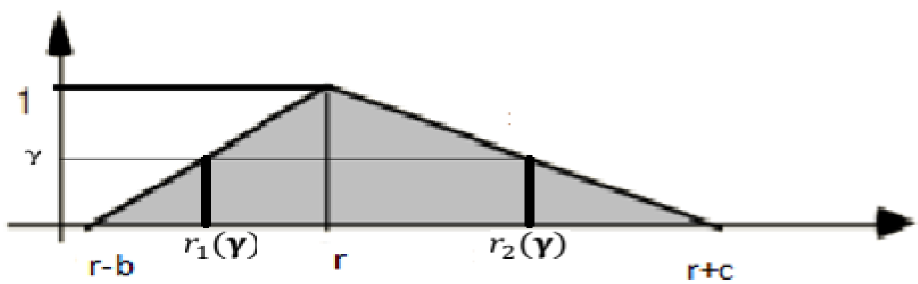

Fig. 1 Triangular fuzzy number (r, b, c) with center r and presentation of $r_1(\boldsymbol{\gamma})$ and $r_2(\boldsymbol{\gamma})$

Because of $r_1(\boldsymbol{\gamma})$ and $r_2(\boldsymbol{\gamma})$ have linear nature then by using simple mathematic rules can obtain:

$$r_1(\boldsymbol{\gamma}) = \mathbf{r} - (1-\boldsymbol{\gamma})\mathbf{b}; \quad r_2(\boldsymbol{\gamma}) = \mathbf{r} + (1-\boldsymbol{\gamma})\mathbf{c}; \quad \boldsymbol{\gamma} \in [\mathbf{0.1}]$$

Definition 2 (Carlsson, Fuller ,2001) the possibilistic mean value of a fuzzy number Let R be a fuzzy number with γ level set [R]γ = [R_1(γ), R_2(γ)]; (γ > 0). So the possibilistic mean value of fuzzy numbers is as below:

$$M(R) = \int_0^1 (R_1(\gamma) + R_2(\gamma))\gamma d\gamma = \frac{\int_0^1 \frac{(R_1(\gamma) + R_2(\gamma))}{2} \gamma d\gamma}{\int_0^1 \gamma d\gamma} \qquad (1)$$

It follows that M(R) is nothing else but the level-weighted average of the arithmetic means of all γ level sets, that is, the weight of the arithmetic mean of R_1(γ) and R_2(γ) is just γ.

Definition 3 (Carlsson, Fuller, 2001) the possibilistic variance of a fuzzy number

$$Var(R) = Cov(R, R) = \frac{1}{6}\int_0^1 (R_2(\boldsymbol{\gamma}) - R_1(\boldsymbol{\gamma}))^2 \boldsymbol{\gamma} d\boldsymbol{\gamma} \qquad (2)$$

Let $R_1(\boldsymbol{\gamma})$ and $R_2(\boldsymbol{\gamma})$ are linear functions applied to TFN R=(r, b, c) with center r. **Guran C. et al. (2015)** proved that possibilistic mean and variance of TFN R=(r, b, c) is calculated after a few integral calculations as below

$$M(R) = r + \frac{(c - b)}{6} \qquad (3)$$

$$Var(R) = \frac{(b + c)^2}{24} \qquad (4)$$

Definition 4 (Carlsson, Fuller, 2001) Let R and W are fuzzy numbers. Then their **fuzzy covariance** is defined as:

Where [R]γ = [$r_1(\boldsymbol{\gamma})$,$r_2(\boldsymbol{\gamma})$] and [W]γ = [$w_2(\boldsymbol{\gamma})$,$w_2(\boldsymbol{\gamma})$]; (γ > 0) then possibilistic covariance of R and W defined as below:

$$Cov(R, w) = \frac{1}{2}\int_0^1 \left(r_2(\gamma) - r_1(\gamma)\right)\left(w_2(\gamma) - w_1(\gamma)\right)\gamma d\gamma \qquad (5)$$

When R=(r, b, c) and W= (w, θ, λ) are TFNs then the related functions become as below respectively:

$$r_1(\boldsymbol{\gamma}) = r - (1-\boldsymbol{\gamma})b;\ r_2(\boldsymbol{\gamma}) = r + (1-\boldsymbol{\gamma})c\ ;$$
$$w_1(\boldsymbol{\gamma}) = w - (1-\boldsymbol{\gamma})\theta;\ w_2(\boldsymbol{\gamma}) = w + (1-\boldsymbol{\gamma})\lambda$$

Then Guran C. et al. (2015) proved that Cov(R,W) calculated as below:

$$Cov(R, W) = \frac{(b + c)(\boldsymbol{\theta} + \boldsymbol{\lambda})}{24} \qquad (6)$$

Notice that if R=W =(r, b, c) then the covariance become Cov(R,R) = $\frac{(b + c)^2}{24}$ which is the variance of TFN R.

Theorem: (Carlsson, Fuller, 2001) Let λ; μ ∈ R and let A and B be fuzzy numbers. Then

$$\text{Var}(\lambda A + \mu B) = \lambda^2\, \text{Var}(A) + \mu^2\, \text{Var}(B) + 2|\lambda\mu|\, \text{Cov}(A, B)$$

Where addition and multiplication operations by a scalar of fuzzy numbers is defined by the sup-min extension principle.

Carlsson and Fullër (2001) proved this theorem which forms the fundamental of the portfolio variance in fuzzy environment. By generalized this theorem is to n fuzzy numbers R_1 , ……. , R_n with constants λ_1,……., λ_n ∈ R, the result can be obtained as:

$$\text{Var}(\lambda_1 R_1 + \lambda_2 R_2 + \cdots \ldots \ldots \ldots . + \lambda_n R_n) =$$
$$\lambda_1^2\, \text{Var}(R_1) + \lambda_2^2\, \text{Var}(R_2) + \ldots\ldots + \lambda_n^2\, \text{Var}(R_n) + 2|\lambda_1 \lambda_2|\, \text{Cov}(R_1, R_2) + \ldots\ldots\ldots\ldots +$$
$$2|\lambda_{n-1} \lambda_n|\, \text{Cov}(R_{n-1}, R_n) =$$
$$\sum_{i=1}^{n} \lambda_i^2\, \text{Var}(R_i) + 2\sum_{i\neq j=1}^{n} |\lambda_i \lambda_j| \text{Cov}(R_i, R_j) \qquad (7)$$

Markowitz's model:

$$\textbf{Min} \quad \text{Var}(R_p)$$

Subject to

$$\text{E}(R_p) \geq \boldsymbol{K} ;$$
$$\sum_{i=1}^{n} x_i = 1 ;$$
$$x_i \geq 0 ;$$

where

$\text{E}(R_p)$: the expected portfolio return, $\text{E}(R_p) = \sum_{i=1}^{n} x_i\, \text{E}(R_i)$

$\text{Var}(R_p)$: The variance of portfolio,

$$\text{Var}(R_p) = \sum_{i=1}^{n} x_i^2\, \text{var}(R_i) + 2\sum_{i\neq j=1}^{n} x_i x_j \text{Cov}(R_i, R_j)$$

$\text{Cov}(R_i, R_j)$: The covariance of returns R_i and R_j

x_i : is money allocated percentage at asset i

$\boldsymbol{K}$: certain return

3. Proposed model

Let the portfolio consisting of **n** assets and operating over next time of one period, **M** denotes the fund's cash level at the start of the period, $\widetilde{R}_i$ denote the fuzzy return at the end of this period, **P** denote the total pension payments plus all additive payments related the plan to be made during this period and **C** denote the contribution to be made during this period obtained by actuaries. Hence we can write the proposed model as

$$\text{Min} \quad \text{Var}(\widetilde{R}_P) = \sum_{i=1}^{n} \text{var}(\widetilde{R}_i)\, x_i^2 + 2 \sum_{j\neq i=1}^{n} \text{cov}(\widetilde{R}_i ; \widetilde{R}_j)\, x_i\, x_j$$

Subject to

$$\text{E}(\widetilde{R}_P) = \sum_{i=1}^{n} \text{E}(\widetilde{R}_i) * x_i \geq \boldsymbol{K} ;$$
$$(1 + \text{E}(\widetilde{R}_P))*(M) + C - P \geq 0; \qquad \text{(insolvency risk)}$$
$$\sum_{i=1}^{n} x_i = 1 ;$$
$$x_i \geq 0; \quad i=1,2,\ldots\ldots,n \qquad \text{(Short sell not allowed)}$$

Where

$E(\tilde{R}_P)$: Expectation of fuzzy return of portfolio
$V(\tilde{R}_P)$: Variance of fuzzy return (risk) of portfolio
K : Required return satisfied the balance in pension plan and secures the fund against insolvency
$cov(\tilde{R}_{i\,;}\tilde{R}_j)$: Covariance between fuzzy returns of assets i,j
M: Fund's reserve of pension plan
C: Contributions paid by scheme's participants
P: Grantees benefits paid by pension scheme plus all administrative expenses
x_i: Proportion at assets i

The adding constraint $(1+ E(\tilde{R}_P))*(M) + C - P \geq 0$ in detail :

This constraint meaning that all money in the fund (M) at start of period after investment optimization i.e. $(1+ E(\tilde{R}_P))*(M)$ plus yearly contributions (C) must be cover all liabilities plus all administrative expenses (P).

The optimized portfolio is found by minimizing the fuzzy variance (risk) for a certain target return level that reserve the pension fund from insolvency risk. This return level is determined by actuary' mathematics rules.

In terms of fuzzy logic, triangular membership functions are used to forecast future returns both because of its suitable nature to the portfolio selection problem and because of its linear structure which facilitates the optimization model.

Now, predict the future return of an asset, assume the membership degree of the fuzzy average is always 1. But the membership degrees will change depending on the scenario whilst deviating vastly from the fuzzy average.

The triangular membership function representing the future returns r_i of the i^{th} asset where i ∈ {1, 2,…....., n}:-

$$\mu_i(x) = \begin{cases} \dfrac{x + b_i - r_i}{b_i}, & r_i - b_i \leq x \leq r_i \\ \dfrac{c_i - x + r_i}{c_i}, & r_i \leq x \leq r_i + c_i \\ 0 \quad , & \text{otherwise} \end{cases}$$

This triangular membership function can be expressed by $(r_i - b_i, r_i , r_i + c_i)$ where b_i and c_i represent maximum possible differences of future returns respectively in down and up directions and r_i is the expected center future return with the highest membership value of 1. After the calculation of r_i, b_i and c_i values of each asset, the fuzzy mean value of the whole portfolio return of n assets can be defined as:

$$M(r) = \sum_{i=1}^{n} M(r_i)x_i \quad ; i =1,…….., n$$

Where x_i represents the proportion of money invested in the i^{th} asset. These proportions satisfy that short selling of any stock is not allowed in the proposed models i.e. $\sum_{i=1}^{n} x_i = 1$; i =1,…….., n

Where the return of i^{th} asset can expressed as (r_i, b_i, c_i) Since r_i is the midpoint of TFN then by eq. 3 we can write the return of i^{th} asset as :

$$M(r_i) = r_i + \frac{(c_i - b_i)}{6}$$

Then the fuzzy mean value of the whole portfolio return of **n** assets as:

$$M(r) = \sum_{i=1}^{n}(r_i + \frac{(c_i - b_i)}{6})\, x_i \;;\quad i = 1, \ldots\ldots, n$$

And according to the model we must define the variance and the covariance for the portfolio as previous method in fuzzy mean value.
As aforementioned the fuzzy variance of the whole portfolio Var(r) equal:

$$\sum_{i=1}^{n} x_i^2 \operatorname{Var}(r_i) + 2\sum_{i\neq j=1}^{n} |x_i x_j| \operatorname{Cov}(r_i, r_j)$$

Guran C. et al. (2015) proved that Var(r) as (**called fuzzy variance of the portfolio**):

$$\operatorname{Var}(r) = \sum_{i=1}^{n} \frac{(b_i + c_i)^2}{24} x_i^2 + 2\sum_{i\neq j=1}^{n} \frac{(b_i + c_i)(b_j + c_j)}{24} x_i x_j = (\sum_{i=1}^{n} \frac{b_i + c_i}{2\sqrt{6}} x_i)^2$$

And they said "***To facilitate the solution of this optimization model, standard deviation can be used instead of variance the risk of portfolio can be the square root of Var(r) and obtained as*** $\sqrt{(\sum_{i=1}^{n} \frac{b_i + c_i}{2\sqrt{6}} x_i)^2} = \sum_{i=1}^{n} \frac{b_i + c_i}{2\sqrt{6}} x_i$

When defuzzified standard deviation is minimized instead of fuzzy variance, the model is transformed to a linear optimization model as below:

$$Min\ \sqrt{Var(r)} = \sum_{i=1}^{n} \frac{b_i + c_i}{2\sqrt{6}} x_i$$

Subject to

$$\sum_{i=1}^{n}(r_i + \frac{(c_i - b_i)}{6})\, x_i \geq K \;;$$
$$\sum_{i=1}^{n} x_i = 1 \;;$$
$$x_i \geq 0;$$
$$0 \leq x_i \leq 1; \quad i=1,2,\ldots,n$$

"

Then the proposed model is transformed to a linear optimization model as below:

$$\operatorname{Min}\ \sqrt{\operatorname{Var}(r)} = \sum_{i=1}^{n} \frac{b_i + c_i}{2\sqrt{6}} x_i$$

Subject to

$$\sum_{i=1}^{n}(r_i + \frac{(c_i - b_i)}{6})\, x_i \geq K \;;$$
$$(1 + \sum_{i=1}^{n}(r_i + \frac{(c_i - b_i)}{6})\, x_i) * M + C - P \geq 0 \;; \quad \text{(insolvency risk)}$$
$$\sum_{i=1}^{n} x_i = 1 \;;$$
$$x_i \geq 0; \quad \text{(Short sell not allowed)}$$

This linear optimization model, $\boldsymbol{K}$ represents the desired minimum portfolio return level and its value determine by actuaries that satisfy balance the pension fund. It is clear that the greater the return, the greater the size of the portfolio risk. On the contrary this not required where the main objective that secures future participant's liabilities and their beneficiaries not have dividends only.

By using alternatives of software programs for solve the model after we determine the required return secure pension fund against insolvency risk.

4. Numerical example to illustrate the model

We can evaluate participants of some Egyptian funds at 30/9/2018 and its data and results as following steps:

Step 1: determine the required rate of return secure the fund and collecting data as:

M (reserve of pension fund at start year) = 378600936 L. E.;

$\boldsymbol{K}(\text{the required rate of return secure the fund}) = 0.15$

P (all expected liabilities at first year) = 85 602 539;

C (expected contribution at first year) = 47 289 513;

The actuary's results:

Table 1. Cash flow for the expected liabilities and contributions

Years	Income	All liabilities
0	47 289 513	85 602 539
1	47 804 241	80 788 060
2	47 797 294	100 910 079
3	47 449 742	107 330 383
4	48 089 326	82 210 994

Table 1 illustrate the promised benefits for the participants and their future contributions, from the evaluation's results sponsor's decisions should be invest the surplus to attain the required rate of return to satisfy fund's balance.

In this part we can point to the case study Egyptian Stock Exchange (EGX). Table 2 shows these stocks. All data in this table consisting of the closing values of six stocks from 10.2012 to 10.2018 are taken from the official web site of Egyptian Stock Exchange, mubasher.com, on a yearly basis total of 7 observation periods

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Table2. Closed market value of the assets

	Assets					
date	EPPK	EXPA	ELEC	VODE	FAIT	ACRO
10/2018	8.41	8.71	0.90	120.00	14.02	25.78
10/2017	5.17	11.98	1.02	73.12	17.17	27.31
10/2016	2.94	6.65	0.72	66.23	5.25	10.75
10/2015	6.61	7.96	0.87	35.55	4.03	13.39
10/2014	7.46	6.71	1.21	80.06	4.40	8.86
10/2013	4.93	5.72	0.71	69.11	4.73	8.67
10/2012	4.54	5.04	0.80	86.90	4.12	4.15

Table 3. The returns of the assets

	Assets					
date	EPPK	EXPA	ELEC	VODE	FAIT	ACRO
10/2018	3.24	-3.27	-0.12	46.88	-3.15	-1.53
10/2017	2.23	5.33	0.30	6.89	11.92	16.56
10/2016	-3.67	-1.31	-0.15	30.68	1.22	-2.64
10/2015	-0.85	1.25	-0.34	-44.51	-0.37	4.53
10/2014	2.53	0.99	0.50	10.95	-0.33	0.19
10/2013	0.39	0.68	-0.09	-17.79	0.61	4.52

Table 3 show the return's values of these six stocks by changes in their closed values as observations along 7 years.

Table 4. the rate of return of assets

	Assets					
date	EPPK	EXPA	ELEC	VODE	FAIT	ACRO
10/2018	0.63	-0.27	-0.12	0.64	-0.18	-0.06
10/2017	0.76	0.80	0.42	0.10	2.27	1.54
10/2016	-0.56	-0.16	-0.17	0.86	0.30	-0.20
10/2015	-0.11	0.19	-0.28	-0.56	-0.08	0.51
10/2014	0.51	0.17	0.70	0.16	-0.07	0.02
10/2013	0.09	0.13	-0.11	-0.20	0.15	1.09

Table 4 show the return's rates of this six stocks by dividing their values on closed market values of each stock as observations along 7 years.

Step 2: By some calculations we can obtain the next parameters:

Table 5. The parameters that used in the model (r_i's , b_i's, c_i's)

assets	EPPK	EXPA	ELEC	VODE	FAIT	ACRO
r_i	0.22	0.14	0.07	0.17	0.40	0.48
b_i	0.77	0.42	0.35	0.72	0.58	0.68
c_i	0.54	0.66	0.63	0.70	1.87	1.06

Table 5 illustrates the necessary calculations of the EGX efficient 6 stocks in order to apply the optimization model.

The proposed model is applied to the 6 stocks. First of all, we should be determining the membership function displaying the future return for each of these 6 stocks. To determine these functions, it is trivially to compute the expected center future return (r_i) since it can be accepted as the average return of the stock where i=1,…, 6. But there is not just a certain rule to estimate the up direction (b_i) and the down direction (c_i) representing the maximum possible differences of future returns. Actually these deviations reflect the expert knowledge. That means this fuzzy model enables that up and down directions can be determined according to the next coming economic conditions i.e. the actuaries can determine this values by experts. But this example, the past observations of the stocks in the last 7 years are observed and under the lights of this information (c_i) and (b_i) are determined due to relatively the best and the worst returns in the past. So the proposed model for this problem as:

$$\textbf{Min } \sqrt{\mathbf{Var(r)}} = \sum_{i=1}^{6} \frac{b_i + c_i}{2\sqrt{6}} \mathbf{x_i}$$

Subject to

$$\sum_{i=1}^{6} (\mathbf{r_i} + \frac{(\mathbf{c_i} - \mathbf{b_i})}{6})\, \mathbf{x_i} \geq K\ ;$$

$$(1+\sum_{i=1}^{6} (\mathbf{r_i} + \frac{(\mathbf{c_i} - \mathbf{b_i})}{6})\, \mathbf{x_i}) * \mathbf{M} + \mathbf{C} - \mathbf{P} \geq 0\ ; \quad \textbf{(insolvency risk)}$$

$$\sum_{i=1}^{6} \mathbf{x_i} = 1\ ;$$

$$\mathbf{x_i} \geq 0; \quad \mathbf{i=1, 2, 3, 4, 5, 6} \quad \textbf{(Short sell not allowed)}$$

Step 3: write model code and have results.

The optimal allocation for the reserve of pension fund to secure the fund and reserve the balance for the pension's plan for the six assets is:-

- Money allocates in asset EXPA = .4798 * 378600936 = 181 652 729L. E

- Money allocates in asset ELEC = .5202 * 378600936 = 196 948 207L. E

Then sponsor's objectives are occur where risk (standard deviation) is minimized which is objective function and equal 0.2098.

5. Conclusion

We have analyzed the management of a pension funding process of a DB pension plan when the short interest rate is the yearly model. Yearly insolvency risk may be solved analytically when the benefits process is a determined under a suitable selection of the technical interest rate and actuary determine the required return rate that does not expose pension fund to insolvency risk.

The components of the optimal portfolio investments in risky and riskless assets are the sum of all terms, and face the actuarial liability, depending on parameters of the randomness of benefits, all expenses and contributions where interest rate is TFN.

We have done a case study of the pension fund and have all required data to show some properties of the model. The decision maker would check the fund's finance status every short certain period.

A portfolio optimization method which minimizes the fuzzy variance of the portfolio is introduced and this method is applied to the 6 well known stocks of Egypt Stock Market. With its fuzzy background this method has some serious advantages compared to the classical MV optimization which is introduced by Markowitz 66 years ago. Firstly, the required return for balance of pension's fund can check short certain period and can reallocate if the required not satisfied. Secondly, the portfolio managers can add their subjective opinions to the model with the help of triangular fuzzy numbers representing the future returns of the stocks. Thirdly, the model carries computation simplicity of the character of the used membership functions. Forth, this method does not require the limitations of classical MV optimization which are listed in detail of the classical MV optimization.

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A Dynamic Model for Sustainable Water Resources Management in Egypt

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Abstract

This work developed a system dynamics model to simulate and analyze the future potential state of water resources in Egypt. The developed model illustrates the concept of water resources availability and needs through the use of causal loop diagrams, stock and flow diagrams, equations, and simulation output graphs. This model shows the feedback and interactions between different variables of the water system. Multi-temporal data were collected to study the dynamic changes in water resources. The developed model will be the base for a decision support tool that enables policymakers to investigate water resources problem in Egypt and achieve the optimal allocation of limited water resources. Also, this work allows long period predictions, which are not available in other published research. The results showed that population growth and agricultural needs are the main factors causing the water crisis in Egypt. They also illustrated that the water needs exceed water availability. In addition, maximizing the utilization of the agricultural drainage water will contribute to reducing this gap.

Keywords: **Simulation Modeling; System Dynamics; Water Adequacy Index; Egypt; Powersim**

1. Introduction

Water is the most vital natural resource on Earth after air where its quantities almost constant. It is essential to humans, plants, and animals to keep alive. In addition, it is important for the ecological balance of the earth. It covers 71% of the Earth's surface. Also, it frames 75% and 80% of human body weight and total composition of most vegetables respectively. Moreover, water shortage or pollution cause 80% of diseases pervasive all over the world. Thus, water needs and the development process are inseparable, as the quantity of water used per day indicates human civilization and progress (State Information Service, 2017).

Nowadays water severe scarcity is a global concern and it is alarming for the future. On the demand side, the rapid growth of population and the fast development of economy worldwide have compelled on a higher water demand. On the supply side, less predictable rainfall due to climate change causes less reliability of water natural sources (Xi and Poh, 2013).

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Sustainable water management needs innovative practices of water management, to balance the different water sectors, meanwhile to provide a good quality and sufficient water in the present and future (Xi and Poh, 2013).

Water is the backbone for sustainable and integrated development in Egypt. Water resources in Egypt are the quota of Nile water, the limit amount of rainfall, underground water, and desalination of sea water and drainage water. The water demand has duplicated as a result of population growth, agricultural extension, tourist uses as well as industrial development and a rise in the standard of living. Egypt's share of Nile water is 55.5 billion cubic meters (BCM) represents 95% of Egypt's total amount of water. Egypt highly depends on Nile water because the rainfall is rare. The per capita share of water in Egypt is 690 cubic meters which is below the water poverty line (1000 cubic meters) (Ministry of Water Resources and Irrigation (MWRI), 2013, P.22). It is going to be reduced in the coming years as a result of the increasing population.

In coming years, Egypt will suffer from serious water shortage and water quality degradation, which results from the population growth and the economic and agricultural expansion. Moreover, disputes about the share of each Nile basin state in water and building Grand Ethiopian Renaissance dam (Millennium dam) increase water crisis (Soliman et al., 2016; MIT's Abdul Latif Jameel World Water and Food Security Lab, 2014; Amer, 2013; Telegraph foreign-staff, 2017). Thus, the officials of water resources management in Egypt need to know the optimal allocation of limited water resources.

"System dynamics (SD) is a powerful methodology and computer simulation modeling technique for framing, understanding, and discussing complex issues and problems" (Radzicki and Taylor, 1997). This approach was innovated by Prof. J. W. Forrester in the Massachusetts Institute of Technology (MIT) in 1956. The benefit of this methodology is that it simplifies the study of a complex system over time. Particularly, it deals very well with the interrelationship between variables and time delays that influence the behavior of the whole system. SD has been well applied to study water and natural resources management, economic growth, demographics, energy systems, business development, environmental systems, and other social systems.

This research aims to develop a dynamic simulation model of water resources in Egypt using system dynamics technique tool. The model defines, analyses and describes water resources in terms of feedback loops and stock and flow diagrams. By identifying the interrelationship between different factors, this model can better serve the analysis of the problem. This model enables decision makers to investigate water resources problem in Egypt and achieve the optimal allocation of limited water resources using multi-temporal data. Finally, such knowledge, related to water, would be obtained by a simple way and with dynamic manner.

This paper is organized as follows: section 2 presents "Literature review". Section 3 introduces "Methodology" which includes these subsections "Simulation modeling", "Problem definition", "Data collection", "Mental model", and "Stock & flow diagram". The model results are presented in section 4. The simulation model is then validated as shown in section 5. Finally, section 6 shows "Conclusion".

2. Literature review

The modeling of water resources that can serve as a decision support system tool is very important in the planning and management of water within the boundaries of states and abroad. It can support the analysis and evaluations of projects concerning with water resources, where it is useful in visualizing and predicting the changes in water supply and demand over the time. Modeling of sustainable water resources management can be conducted by different methods; such as using System Dynamic Simulation Modeling (Xi and Poh, (2013); Adamowski and Halbe, (2011); Zhang et al., (2009); Duran-Encalada et al., 2017; Kotir et al., 2016), Expert Knowledge (Safavi et al., 2015), Fuzzy Logic (Sharma et al., 2012; Raju and Kumar, 2003), Mathematical Programming (Afify, 2010; Georgakakos, 2012; Anyata et al., 2014; Abdel Gawad et al., 1995), the Geographic Information System (GIS) and Remote Sensing (Guo et al., 2010).

Xi and Poh (2013) developed an SD model called Singapore Water to demonstrate that SD is a powerful decision support technique to help achieve sustainable water resource management in Singapore. Zhang et al. (2009) developed a dynamic model based on water resources carrying capacity theory for water resource management using the SD technique.

Sharma et al. (2012) used the fuzzy logic technique in water management system to study Pawana River water quality in linguistic terms. Raju and Kumar (2003) employed fuzzy logic based multicriteria decision making for selecting the best alternative of irrigation subsystem. The performance criteria (indicators) are the conjunctive use of surface and groundwater resources, environmental impact, the participation of farmers, social impact, productivity, and economic impact. These criteria are evaluated for four irrigation subsystems of the Sri Ram Sagar Project, Andhra Pradesh, India to select the best among them.

Afify (2010) used Multi-criteria Decision Analysis for ranking and selection among all possible desalination alternatives for Egypt, considering the consumption of desalinated water, sites of the plants, and their capacities, source of feed water, and desalination technology. Georgakakos (2012) used linear programming to formulate the objective functions and constraints of water allocation problem to assist Castaic Lake Water Agency with decisions to meet annual water demands. Anyata et al. (2014) applied a mathematical model of discrete dynamic programming problem to predict the demand, consumption and net benefit of the conjunctive use of the surface water and groundwater resources at the University of Benin, Benin City, Edo state, Nigeria.

Drainage Research Institute in Egypt developed the Simulation of Water Management in the Arab Republic of Egypt (SIWARE) model as a decision support system to show the impacts of changes in the agricultural water management in three parts of Nile Delta (Western, Middle, and Eastern Delta) (Abdel Gawad et al., 1995). SIWARE is an integrated mathematical and continuous time model based on real physics. Until now, there are no published investigations in using SD as a decision support technique to study the Egyptian's sustainable water resources management.

Zaghloul et al. (2012) conducted a study to address the current and projected availability of Egyptian water needs and water resources. In their study, familiar Statistical methods were used based on Egyptian Water Resources and Irrigation Ministry data, and various sources involved in this field such as National water research center. This study expected that Egyptian water needs reach about 86.18 billion m3 in the year 2025, whereas the total water resources is expected to be in 2025 about 76.86 billion m3.

This paper develops a subsystem diagram of water resources management in Egypt based on previous researchers, studies and experts, mainly (Zhang et al., 2009), (Xi and Poh, 2013) and (MWRI, 2013). The configuration of this subsystem involves 4 major subsystems and minor 7 subsystems as shown in Figure 1. The major subsystems are water demand, water supply, water uses and water surplus/shortage. Water demand determines the quantity of water that Egypt needs per year. Water supply determines the quantity of water available annually. Water uses defines the amount of water uses yearly. Finally, water surplus/shortage shows the abundance or deficits of water per year. When there are some deficits in water, the government should increase the funding for the water sector to build more wastewater and desalination water plants. Also, the increase in GDP leads to an increase in the economic activities and standard of living, thus increasing the water demands.

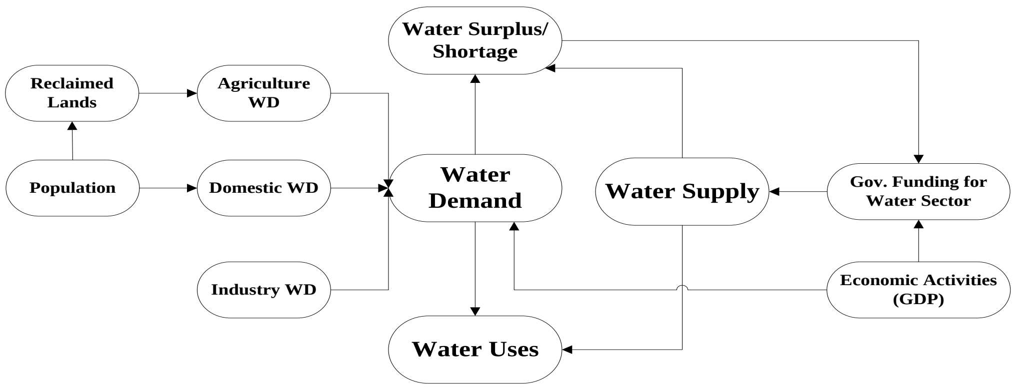


Figure 1 Subsystem diagram for water resources management in Egypt.

The main five differences between this research and the previous work on water resources management in Egypt are the following:

1- This research uses the system dynamics method for developing a dynamic simulation model of water resources in Egypt, which has not been implemented to study the Egyptian's sustainable water resources management before. The SD approach shows the big picture of any problem and highlights its main feedback loops, i.e. SD is a comprehensive and holistic approach to problem-solving.

2- The SD model identifies the interrelationship between different factors (such as the effect of economic activities on population, the standard of living on water demand, and the demand of land reclamation on water demand of the agriculture). The literature does not indicate clearly the relationships among the factors influencing water resource management in Egypt. Identifying these factors and their interrelationships contribute to raising awareness of determining the dimensions of the investigated problem and predicting the future water needs and realistic availability of water in the long term.

3- This research combines water resources, water needs, and water uses in feedback loops, while other researches do not have these feedbacks.

4- This model enables decision makers to investigate water resources problem in Egypt and achieve the optimal allocation of limited water resources using multi-temporal data.

5- In this work, we made forecasts till the year 2035, which are not available in other published research.

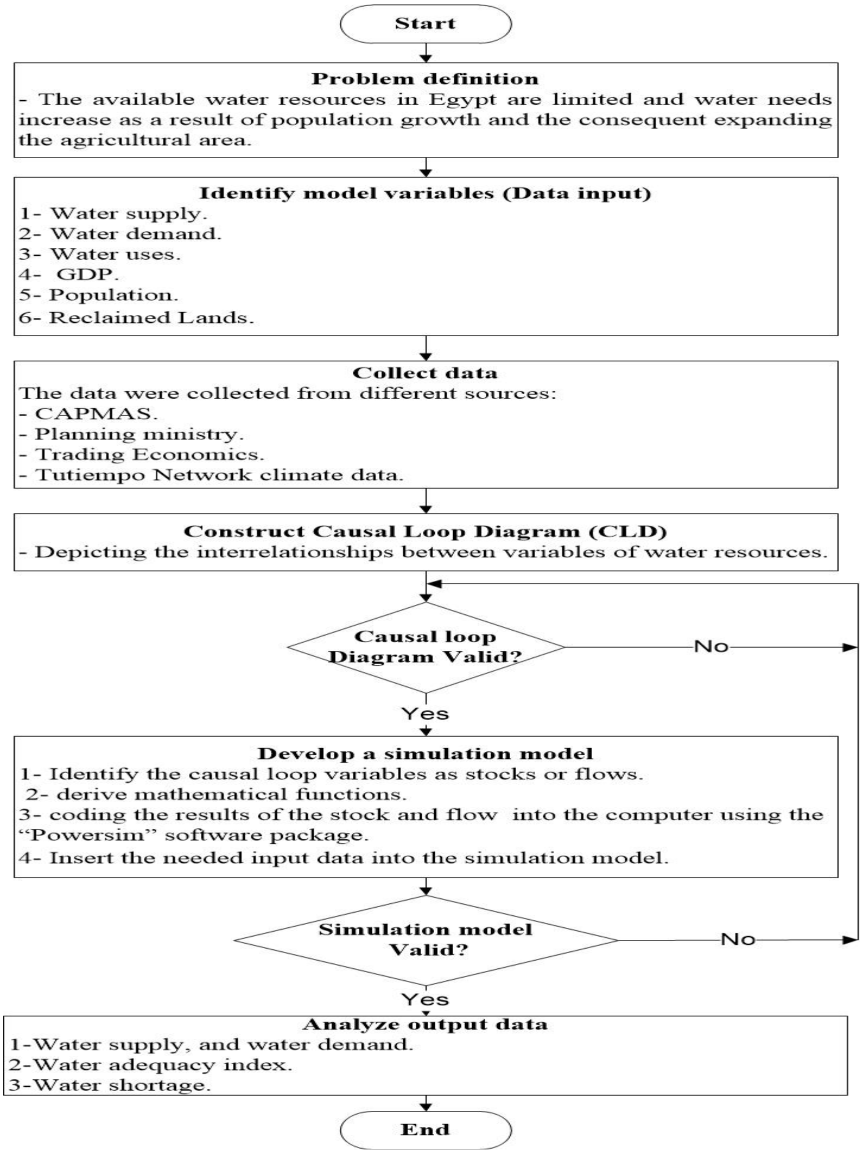
3. Methodology

3.1 Simulation modeling

The developed model is a dynamic model for sustainable water resource management in Egypt. The authors use the system dynamic modeling software "Powersim" for developing the model. It is simulation software based on the system dynamics technique for providing the modelers with higher capabilities to make complex business simulators. Flowchart 1 shows proposed methodology of building a dynamic simulation model of water resources in Egypt. The presented model applies SD as a decision support tool to help achieve sustainable water management in Egypt and analyze the long-term impacts of various investment plans. In addition, the model presents the feedback between various variables.

3.2 Problem definition

The most critical stage in building a model is the problem articulation. What is the issue the participants or users are most worried about? What are the problem and the purpose of the model? Before defining the problem, the authors made twenty-two interviews with twenty individuals of stakeholders who are involved in water resources problems in Egypt. The interviewees represented different organizations, including MWRI, National Water Research Center (NWRC), the National Authority for Remote Sensing and Space Sciences (NARSS), and a number of farmers and citizens. They are decision makers, researchers, farmers or citizens. The authors choose the MWRI because of its responsibility of water resources and irrigation. NWRC was chosen because it is considered the large research center in the water field. The authors also selected NARSS as it is one of the largest research centers in Egypt where water is one of the main research areas. In addition, they selected farmers because they are an essential element involved in water resources problem, where they use a large amount of water to irrigate their lands.



Flowchart 1 A proposed methodology of building a dynamic simulation model of water resources in Egypt

In these interviews, the authors initially gave the stakeholders an overview of their study to enable them to share ideas and information. The stakeholders gave some advice, information and some references to know the problem deeply. Through these interviews, the authors were able to reach a good definition to the problem of water in Egypt, where the available water resources are limited and water needs increase as a result of population growth and the consequent expanding the agricultural area. Based on these interviews, we have identified variables that influence water resources management in Egypt.

3.3 Data collection

With reference to the result of the identified factors, the data required was collected from the year 2004 to 2015. The data were collected from different sources (e.g. Central Agency for Public Mobilization and Statistics (CAPMAS), 2009-2017, (2013); Planning ministry, (2016); Trading Economics, (2016)). For example, Supply and demand water were collected from (CAPMAS, 2009-2017), climatic data such as rainfall and potential evapotranspiration were gathered from (Tutiempo Network climate data, 2016), GDP from (Trading Economics, 2016).

Also, because of limited information and the lack of official data for some variables, presumptions have to be made during model building. The primary assumption is the agriculture water demand is 10% higher than the known agriculture water uses. Secondly, due to some variables change slightly over time, we assume that they are constant during model set up (i.e. rainfall amount, underground water and desalination water).

Statistical analysis was carried out on the collected historical data to get equations that well represent changes in exogenous variables over time (The model equations were illustrated in appendix A).

3.4 Mental model (Causal loop diagram)

The causal loop diagram (CLD) is a significant tool for depicting the interrelationships between variables of water resources. The pool of variables, used in developing the casual loop diagram and stock and flow diagram, were deduced from previous researches, studies, and Experts (Xi and Poh, 2013; Adamowski and Halbe, 2011; Zhang et al., 2009, Ministry of Water Resources and Irrigation, 2005; Koca et al., 2012; Sharawat et al., 2014). The presented causal loop diagram is made of total 23 variables, which are mainly classified into water supply, water demand, water withdrawal, water surplus, and water shortage categories.

After making the causal loop diagram, the authors showed them to three persons of stakeholders from different organizations to know their opinions and validating the causal loop diagram. These stakeholders are researchers and experts at NWRC and NARSS who worked in the water field and share in the national and international project. The authors helped them to understand system dynamic and

CLD by giving them an overview and an example so that they could express their opinions. The opinions of expert professors and researchers are valued and the best way to validate the CLD. After meeting the interviewees, the authors incorporated their inputs and comments in the causal loop diagram. Figures 2-5 depicts the causal and loop diagrams of the model.

Positive/negative signs related to each arrow represent relationships between variables in the CLD. The arrows clarify effect directions while the signs at the end of the arrows are effect signs. A positive sign indicates that both variables change in the same direction. For example, as shown in Figure 2, the interaction between population variable and water demand of domestic uses variable has a positive sign. Thus, the increase of population leads to increasing water Demand for domestic uses. And vice versa, for example, the negative sign interaction between water demand variable and water adequacy index variable presented in Figure 2, where the increase of water demand leads to the decrease in water adequacy index. Furthermore, to form a loop; at least two variables having the same direction are needed. If the loop only has a positive sign or even number of negative signs then it is called a reinforcing (positive) loop as shown in Figures 2, 3. Otherwise, it is called a balancing (negative) loop as presented in Figure 5.

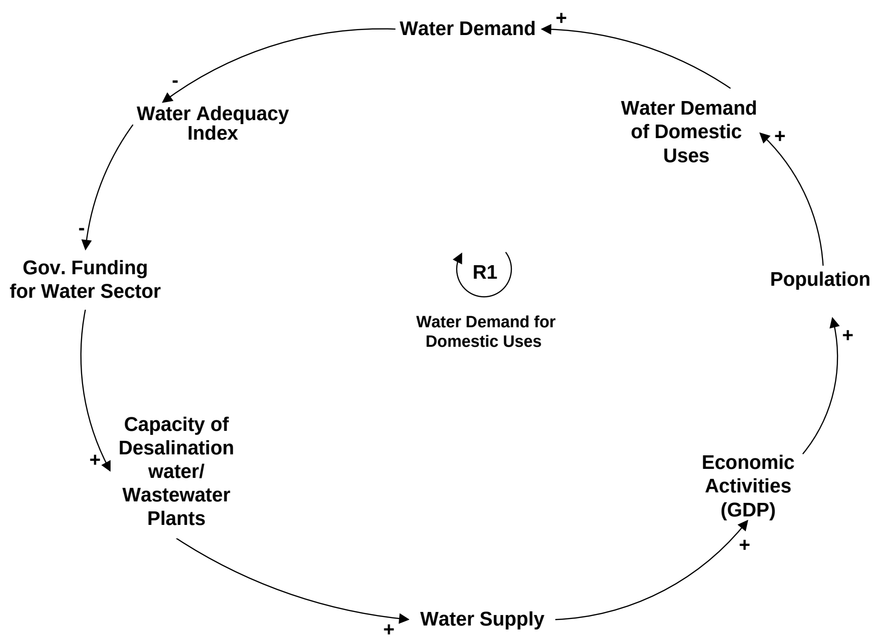


Figure 2 Water demand for domestic uses loop.

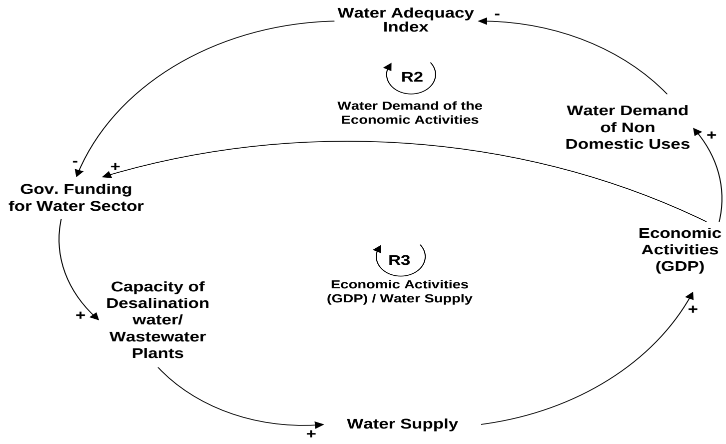


Figure 3 Effect of economic activities (GDP) on water supply loops.

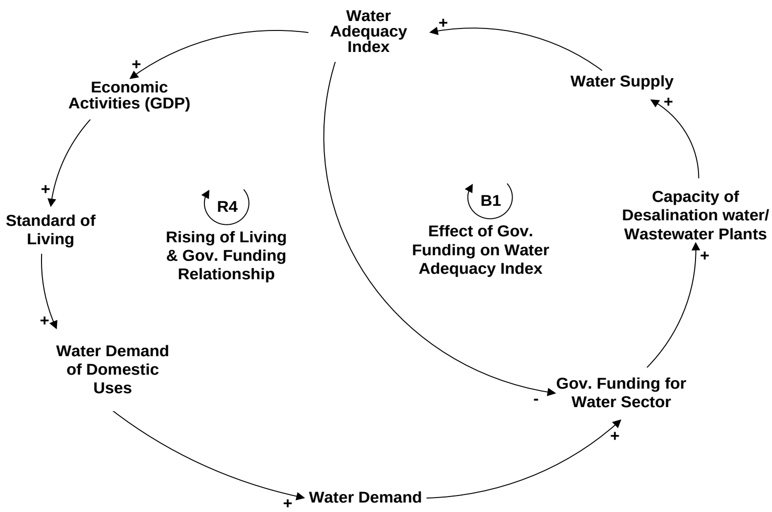


Figure 4 Government funding for water sector loops.

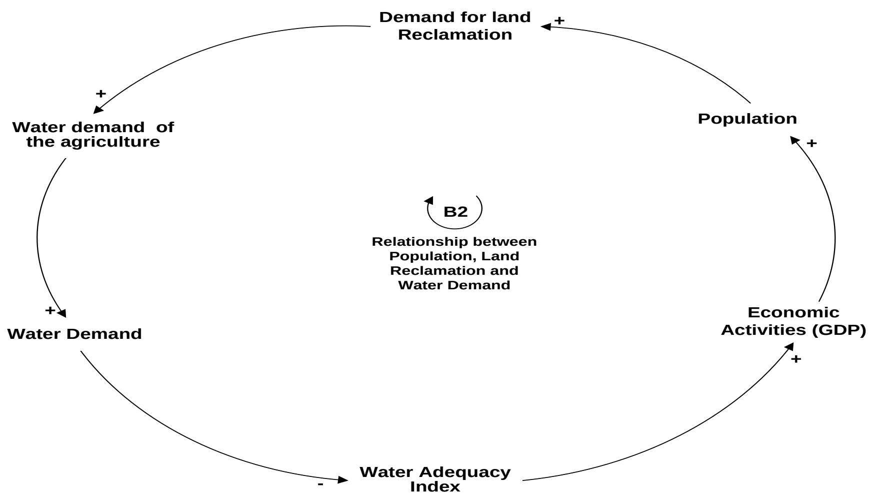


Figure 5 The relationship between Population, land reclamation and water demand loop.

3.5 Stock and flow diagram

Developing the stock and flow diagram are required for the simulation model. The initial step is to identify the causal loop variables as stocks or flows. The following step is to derive mathematical functions that relate each variable to each other. The results of the stock and flow are then coded into the computer using the "Powersim" software package. The needed input data is consolidated and inputted into the simulation model. Appendix B presents the stock and flow diagram of the model.

4. Simulation model Results

4.1 Data input to the model

The model is constructed to interpret and simulate water demand, supply, and uses in Egypt. Table 1 displays the model variables, and their initial values. The model is run from the year 2004 to 2035. These data are real measured data from national/ international organizations.

Table 1 The initial data input to the model

No.	Variable	Units	Value
1	Nile water	Billion m^3	55.5
2	Under Ground Water	Billion m^3	6.1
3	Rainfall	Billion m^3	1.17
4	Drainage water	Billion m^3	4.8
5	Waste water treatment	Billion m^3	1
6	Sea water desalination	Billion m^3	0.067
7	Industry water demand	Billion m^3	1.1
8	Agriculture water demand	Billion m^3	64.13
9	Domestic water Demand	Billion m^3	5.6
10	Water Evaporation	Billion m^3	0
11	Mean Temperature	°C	22.4
12	Population	Thousand Person	68,648
13	Standard of Living	$	1216.11
14	Reclaimed Lands	Thousand Feddan	23.5
15	Economic Activities (GDP)	Billon $	78.85
16	Gov. funding for water sector	Billion L.E	1.1
17	Capacity of waste water plants	1000 m^3/day	15000
18	Domestic uses	Billion m^3	—
19	Agricultural uses	Billion m^3	—
20	Industrial uses	Billion m^3	—
21	Water Supply	Billion m^3	—
22	Water Demand	Billion m^3	—
23	Water adequacy index	Percentage	—
24	Water withdrawal	Billion m^3	—
25	Water Surplus	Billion m^3	—
26	Water shortage	Billion m^3	—

4.2 Outputs

The model outcomes are presented in (Figures 6-11) and the data cover 32 years from 2004 to 2035. The results showed that Egypt's population would increase from about 69 million in the year 2004 to 160 million in the year 2035 as shown in Figure 6. This increase leads to rising domestic water demand per year from about 5.6 billion m^3 in the year 2004 reaching 18.9 billion m^3 in the year 2035 as indicated in Figure 7. The increase in population requires increasing agricultural land, establishing new factories, and expanding services and therefore increasing demand for water. This expectation can be confirmed by loops revealed in Figures (2, 5). Also, this increase in population leads to increasing total water demand from about 73.1 billion m^3 in the year 2004 to 93.84 billion m^3 in the year 2035 as shown in Figure 7.

Figure 7 shows that the agriculture sector represents the largest share (82 %) of water demand in Egypt between the different sectors. Figure 8 represents water resources in Egypt. This Figure indicates that all water resources seem-fixed except for agricultural drainage water that expected to increase from about 4.8 billion m^3 in the year 2004 to 23.68 billion m^3 in the year 2035. This means that officials should find unconventional ways to increase the amount of water available. From analyzing the results of water demand and water supply, the authors found that there is a water shortage, thus inadequacy in water as indicated in Figures 9, 10.

As shown in Figure 11, the water withdrawal (uses) incremental over time. This increase results from the rapidly growing population, the agricultural extension uses as well as industrial development and a rise in the standard of living. The effects of this increase can be confirmed by loops clarified in Figures (2, 4).

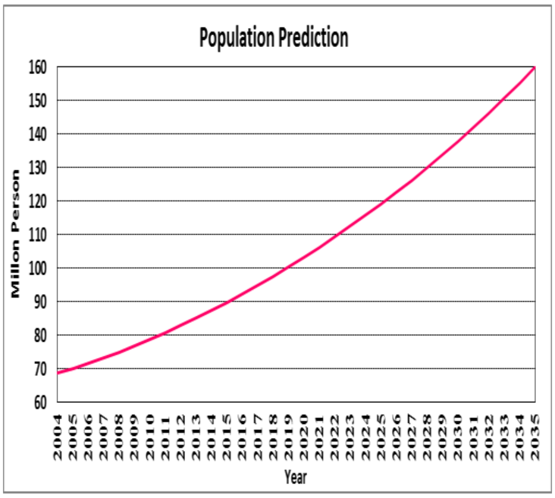


Figure 6 Egypt's population

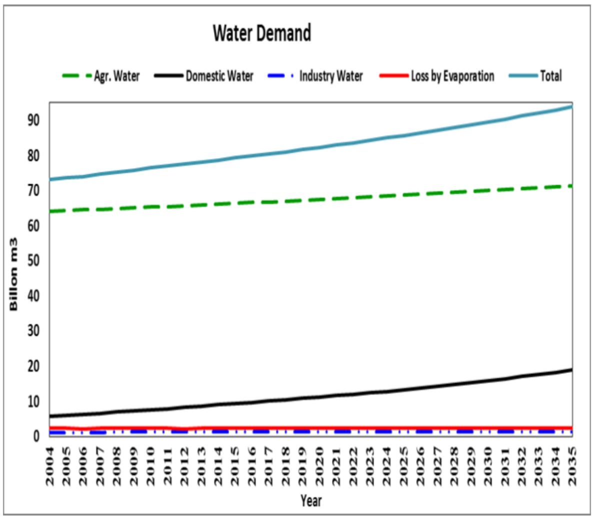


Figure 7 Water demand

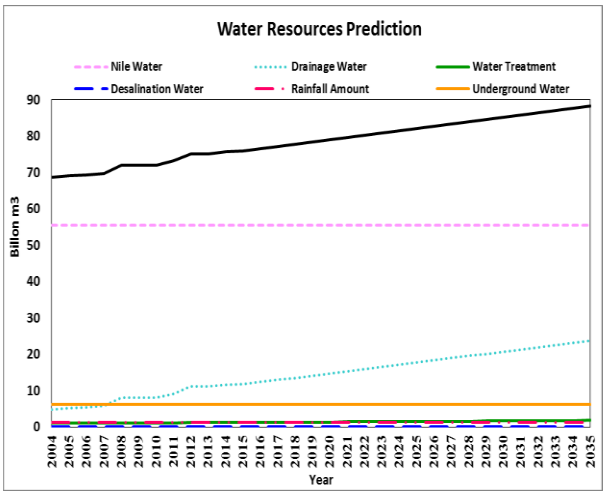


Figure 8 Water resources

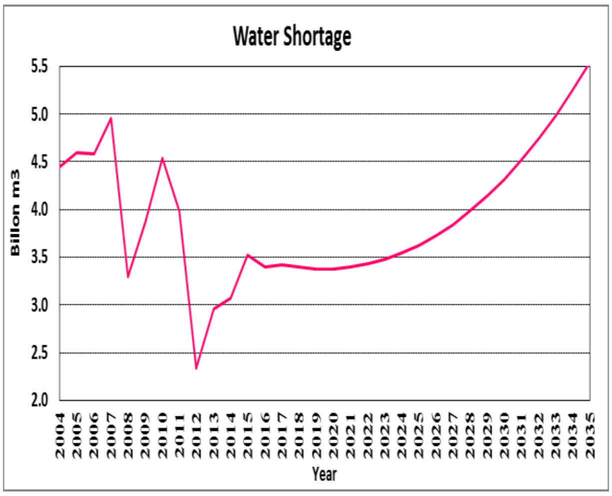


Figure 9 Water shortage

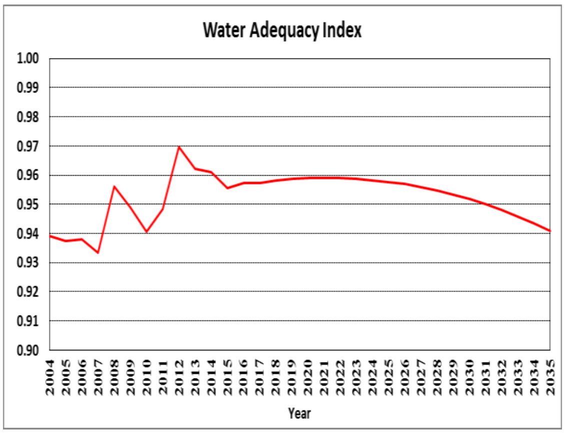


Figure 10 Water Adequacy Index

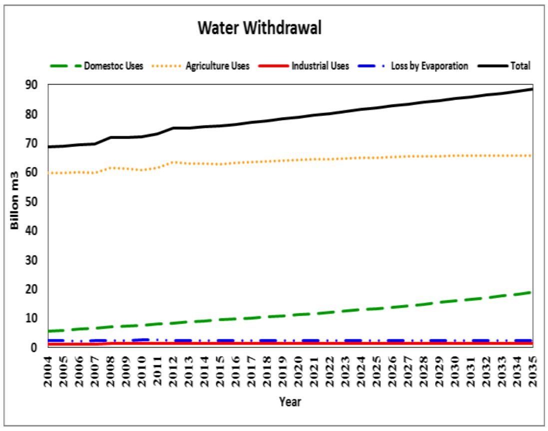


Figure 11 Water withdrawal (Uses)

5. Model validation

To increase the confidence of water resources management in Egypt SD model, the authors executed model calibration and direct structural tests and gathered experts' opinion. Model calibration is "the process of estimating the model parameters (structure) to obtain a match between observed and simulated structures and behavior" (Olava, 2003). Direct structural tests assess the validity of the model structure, by directly comparing the simulated reference mode with knowledge about the real system (Barlas, 1996). In addition, the most frequent techniques in generating and evaluating policies in models of dynamic systems are exploratory scenarios (what-if scenarios) and exhaustive testing by experts. (De Salles et al., 2016).

By comparing the prediction of Egypt's population resulting from the model in the year 2017 with the census of Egypt in the same year (CAPMAS, 2017, p. 1), the authors found that the model estimation is 94,849 million person and the census is 94,798. This means that the population estimated of the model and that of the census are approximately the same. Also, the GDP forecast of the model in the year 2016 is 336.4 billion $, where the GDP according to world bank in the same year is 332.8 (The World Bank Group, 2018). In addition, according to (Zaghloul et al., 2012) Egypt's water needs in the year 2025 is 86.18 billion m^3, while in the model is 85.6 billion m^3 with a change in the result equals 0.7 %. Also, water resources in Egypt in the year 2015 was 76.4 billion m^3 (CAPMAS, The year 2017, P. 173), while in the model is 75.74 billion $m^3$with a change in the result equals 0.86 %. Besides calibration, direct structure test is useful in increasing the dependability of the model. In a real system, the population increases with the rate of 2.3% per year from 2004 to 2015, where the model prediction is 2.5% (Approximately the same). Finally, to ensure the validity of the model, the authors viewed the results of the model to an expert in water and confirmed the validity of the results and the likelihood of occurrence in the future if there are no emergency circumstances in the coming period.

6. Conclusion

A system dynamics model for sustainable water resources management in Egypt containing a causal loop diagram and a stock-and-flow diagram has been developed. This model enables decision makers to the optimal allocation of limited water resources and analyzes the long-term impacts of various investment plans. The researchers use the system dynamics as an approach to analyze and understand the cause and effect of all water resources significant variables and their relationships. It illustrates the concept of water resources through equations and simulation output charts and shows the internal feedback between variables.

The information generated from investigating the outcome of basic runs is valuable to determine the amount of water supply from different sources and water demand for different sectors in the future. Also, this information will enable the decision makers to put the best policies to make water balance between supply and demand and achieve substantial utilization of available water resources. The basic runs reveal the fact that population growth and agricultural needs were the most influential causes of water crisis (shortage) in Egypt and there is an inadequacy in water. Also, they show that the recycling of agricultural drainage water can help in decreasing the gap between water needs and water supply.

Finally, the researchers suggest to put into place the following policies to overcome this shortage:

1. Improving irrigation and draining systems.
2. Using cropping patterns and minimize the cultivated area with high water consuming crops especially rice, bananas, and sugarcane.
3. Changing farm irrigation systems.

4. Development of short-lived plants
5. Upgrade water infrastructure.
6. Increase awareness about water challenge between all stakeholders and enable them to participate in water policy decisions
7. Achieving the concept of virtual water in a precise way.

Acknowledgment

The authors would like to thank Assoc. Prof. Sherein Zahran, the director of Climate Changes department, The Environment and Climate Research Institute, NWRC for her valuable guidance and Dr. Mohammed A. El-Shirbeny the Assoc. Prof. of Irrigation Water Management, Agricultural applications Department, NARSS.

List of abbreviations

Abbreviation	Explanation
SD	System Dynamic
CLD	Causal Loop Diagram
WD	Water Demand
MWRI	Ministry of Water Resources and Irrigation
NWRC	National Water Research Center
CAPMAS	Central agency for public mobilization and statistics
NARSS	National authority for remote sensing and Space Sciences

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Appendix

Appendix A

The main equations of the model are the following:

Eq. (A.1): Population Stock

INIT Population = 69997.

Flow Population = +dt* Population Rate.

Population Rate = Fractional Population Rate * Population.

Fractional Population Rate = Normal Fractional Pop Rate * Effect of GDP on Population.

Eq. (A.2): Domestic Water Demand

Domestic Water Demand (WD) = Normal Domestic WD * Effect of Population on Domestic WD * Elasticity of Standard Of Living on Domestic WD.

Eq. (A.3): Agriculture Water Demand

Agriculture Water Demand = Normal Agriculture WD * Effect of Reclaimed Lands on Agriculture WD.

Eq. (A.4): Industry Water Demand

Industry Water Demand = Normal Industry WD * Effect of GDP on Industry WD.

Eq. (A.5): Water Supply

Water Supply = Nile Water + Drainage Water + Underground Water + Rainfall Amount + Water Treatment + Desalination Water.

Eq. (A.6): Water Demand

Water Demand = Agriculture WD + Domestic WD + Industry WD + Water Evaporation.

Eq. (A.7): Water Adequacy Index

Water Adequacy Index = $\frac{\text{Water Supply}}{\text{Water demand}}$.

Eq. (A.8): Water withdrawal

Water withdrawal (Uses) = Agricultural Uses + Domestic Uses + Industrial Uses + Loss by Evaporation.

Eq. (A.9): Water Surplus

Water Surplus = Water supply – Water withdrawal.

Eq. (A.10): Water shortage

Water shortage (deficits) = Water demand – Water Supply.

Appendix B

The following figures show the stock and flow diagrams of the model (Figures B.1- B.6).

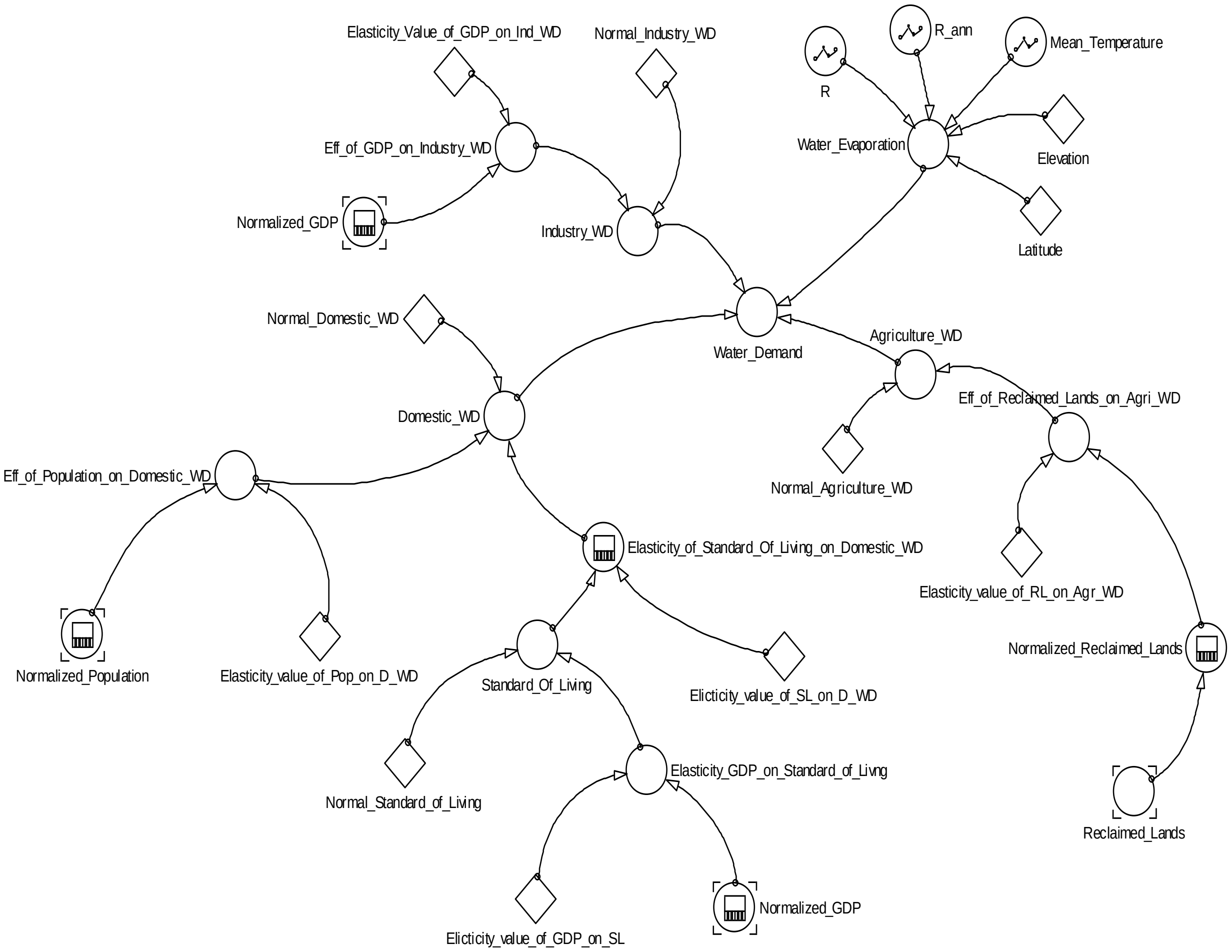

Figure B.1 Water Demand

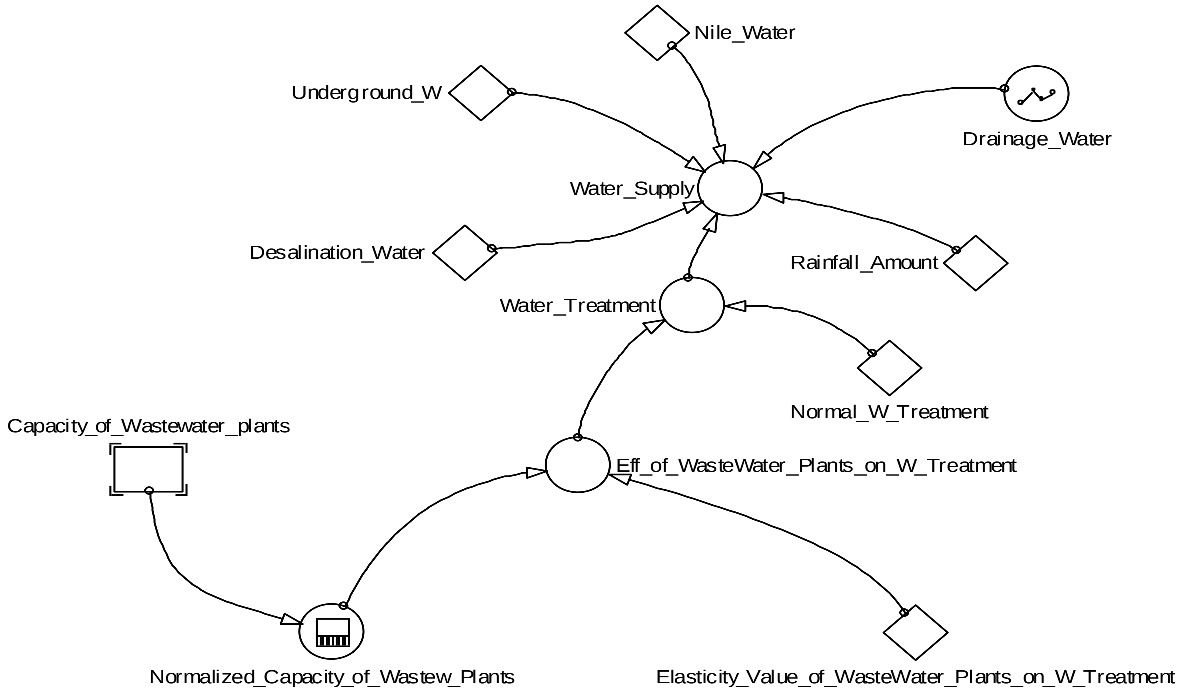

Figure B.2 Water supply

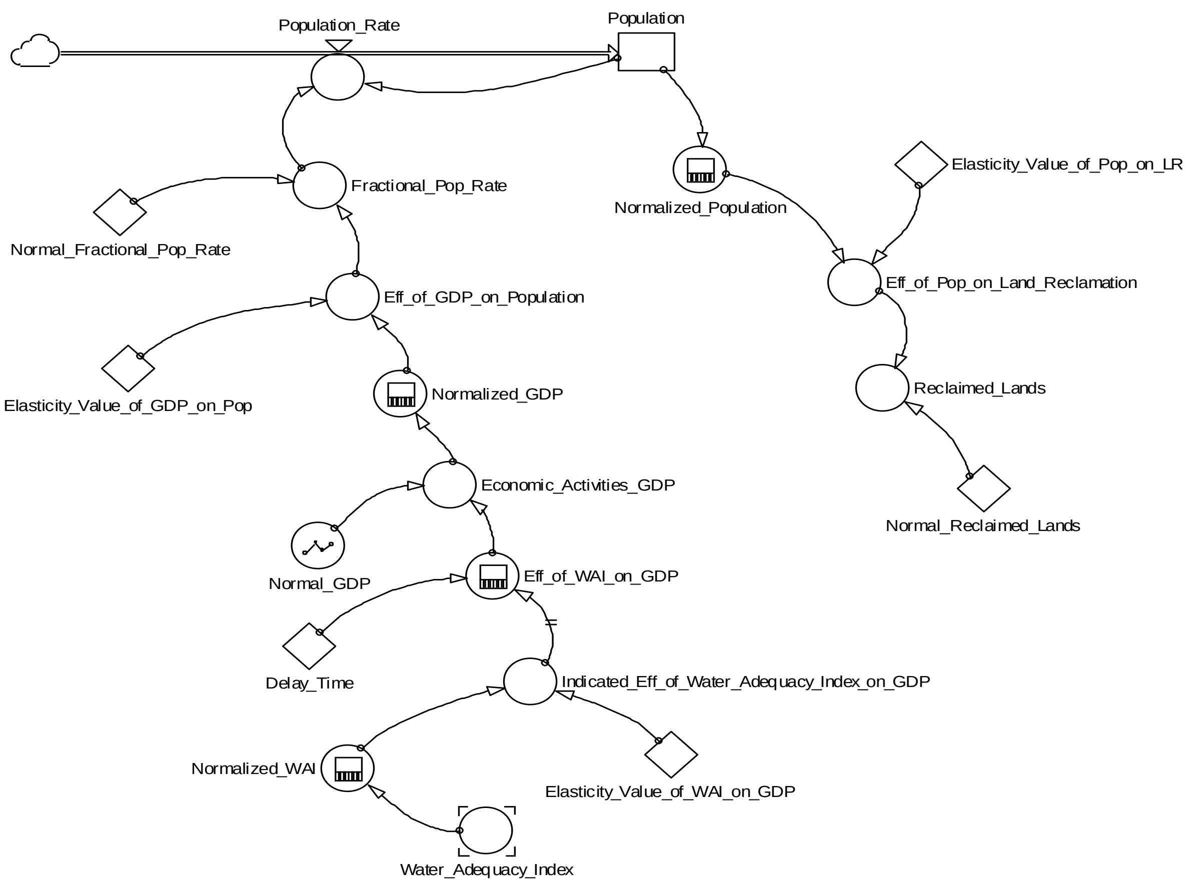

Figure B.3 Population

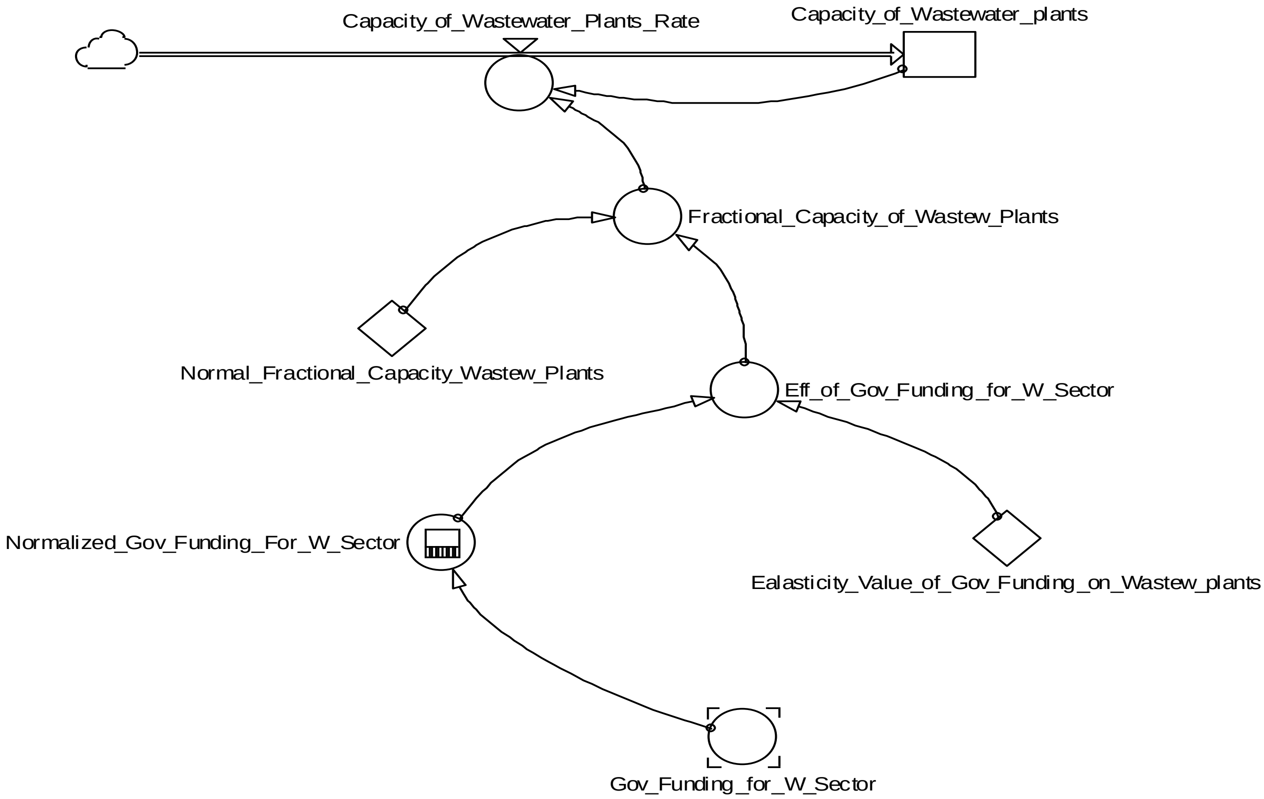

Figure B.4 The capacity of wastewater plants

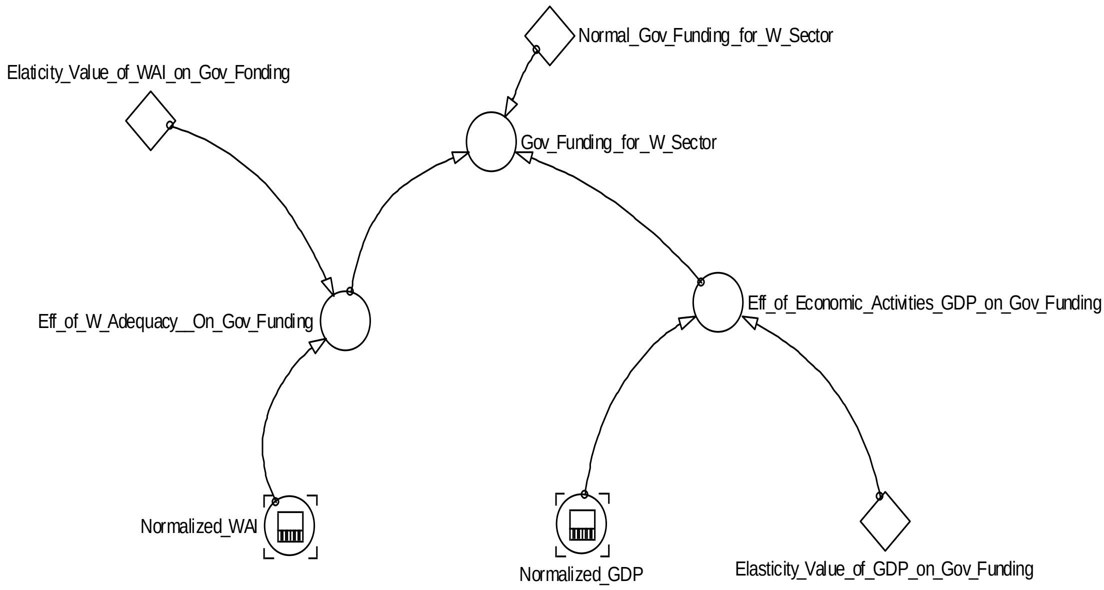

Figure B.5 Government funding for the water sector

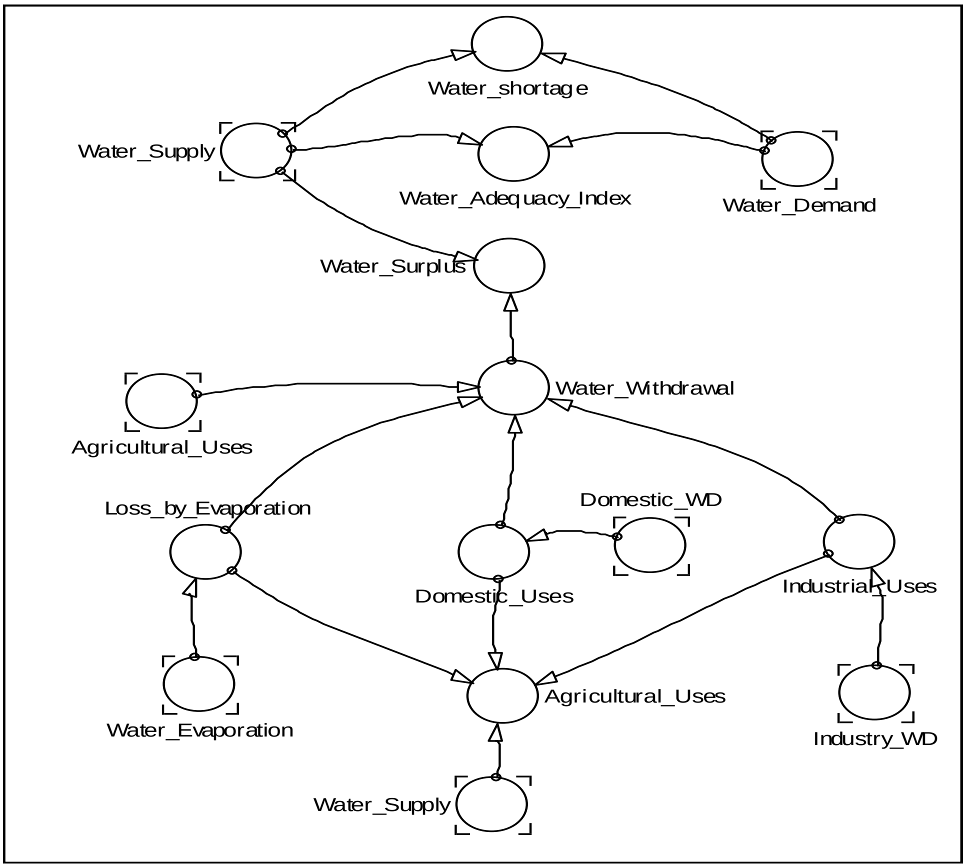

Figure B.6 Outputs of water resources management in Egypt model

The Literature Review of De Novo Programming Technique

Naglaa Ragaa Saeid (1), Hany Gamal EL – Din (2)

Abstract

Most operations research methodology concentrates on the redesign and improved function of existing systems. Very little methodology and efforts are devoted to the design of systems De Novo. Using De Novo programming, several approaches for examining planning problems are described where the objective is not simply to optimize a given system, but to design an optimal system. De novo programming, a system design approach which links system flexibility, efficiency, and optimal system design. It is show that within multi-objective decision making framework, de novo programming may allow the decision maker to achieve an ideal or meta-optimal system performance, or improve the performance of compromise solutions, through the modification or shaping of the feasible region of decision alternatives. This paper represents a brief review over De Novo programming, Literature Review provides a brief insight about the De Novo programming and its applications.

Keywords: Optimization- De Novo Programming – Operations Research Techniques Redesign Systems

1. Introduction

Taha (2010) defined the science of Operations Research (OR) is a quantitative approach to decision making, it's both an art and a science, the art of modeling

the problem and the science of solving the model using (precise) mathematical algorithms. The notion of optimality and the process of optimization are pivotal to the areas of economics, engineering, as well as management and business, etc. Zeleny (1986) introduced a new way of resolving multiple-criteria decision making problems called the De Novo programming to pursue the requirements of modern production which characterized by no-waste, no-buffer, just-in-time operations, full utilization of scarce resources, multiple objectives (quality, worker satisfaction, profits, etc.), and continuous flexibility of design and redesign of systems. Zeleny (1990) explained the purpose of optimizing the system cannot be just to improve the performance of a given, pre-configured system but rather to find the best system configuration itself, i.e., design an optimal system.

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Many Researches like Optimal Design rarely dealt with system design, its configuration or re-configuration. Rather, they focused on valuation of a given system, searching for decision or design variables that maximize a single or multiple measurement criteria or objectives. This review will discuss a theory and methodology of optimal system design embodied in De Novo programming and its applications. This paper is organized as follows: Section (2) introduces the De Novo programming, the general model of the De Novo programming, the formulation of its iterations, and the optimum-path ratios in De Novo programming as alternatives for selecting the optimal system designs to solve De Novo programming problems. Section (3) represents a brief review over De Novo programming providing a brief insight about the De Novo programming and its applications. Section (4) represents the analysis & summary of literature review including the applications used, the methods and techniques applied, and the types of applications on the De Novo programming in categories with percentage. Section (5) discusses the conclusion, the main points of this paper, and its applications.

2. The De Novo Programming

Chen (2008) explained the utilization of De Novo programming to build an efficient planning model of resource allocation. De Novo programming was proposed by Zeleny to redesign or reshape given systems to achieve an aspiration/desired level. The original idea was that productive resources should not be engaged individually and separately because resources are not independent.

When we usually confront a situation that is almost impossible to get optimize all criteria in the real world. We should be to do alternative of all the criteria, this property is so called *trade-offs*. It is a *trade-offs* concept for limitation resource of firm operations level. The scholar Zeleny (2005) suggested trade-offs are properties of inadequately designed system and thus can be eliminated through designing better, preferably optimal system. So, De Novo programming can deal with a multiple criteria optimization problem. We except to build a planning model based on De Novo programming for resource allocation.

Zeleny (2010) represented the general model of De Novo programming by denoting the available amounts of resources $\boldsymbol{b_i, i = 1, \dots, m}$ and their prices $\boldsymbol{p_i}$, then $\boldsymbol{p_1 b_1 + \cdots + p_m b_m}$ represents the total valuation of resources. The individual $\boldsymbol{b_i}$'s are not "given" constants but rather decision variables affecting the value of the objective functions involved. Suppose that $\boldsymbol{B}$ indicates the amount of money available (budget) for the purchases of the resources. We want to maximize profits $\boldsymbol{C}$ for single or multiple objective problems, and the representation of the resource allocation *economic problem* can be formulated in the following LP model:

$$\textbf{\textit{Maximize}}\ \boldsymbol{Z = CX}$$

$$\textbf{\textit{s.t.}}\ \boldsymbol{AX - b \le 0\ ,\ pb \le B\ , X \ge 0} \qquad (1)$$

Where $C \in R^{q*n}$ and $A \in R^{m*n}$ are matrices of dimensions $q \times n$ and $m \times n$ respectively, and $b \in R^m$ is m-dimensional unknown resource vector, $X \in R^n$ is n-dimensional vector of decision variables, $p \in R^m$ is the vector of the unit prices of m resources, and $\boldsymbol{B}$ is the given total available budget.

Solving problem (1) means finding the optimal allocation of B so that the corresponding resource portfolio ***b*** maximizes simultaneously the values $Z = CX$ of the product mix ***x***. Obviously, we can transform problem (1) into:

$$\textbf{\textit{Maximize}}\ \boldsymbol{Z = CX}$$

$$\textbf{\textit{s.t.}}\ \boldsymbol{VX \le B\ , X \ge 0} \qquad (2)$$

Where $Z = (z_1, \dots, z_q) \in \mathrm{R}^q$ and $V = (v_1, \dots, v_n) = pA \in \mathrm{R}^n$.

Let $\boldsymbol{z_{k*}} = max\ \boldsymbol{z_k}\ ,\ \boldsymbol{k = 1}, \dots, \boldsymbol{q}$, be the optimal value for $\mathbf{k^{th}}$ objective of Problem (2) subject to $VX \le B, X \ge 0$.

Let $z^* = (z_{1*}, \dots, z_{q*})$ be the q-objective value for the ideal system with respect to $\boldsymbol{B}$. Then, a *meta-optimum problem* can be constructed as follows:

$$\textbf{\textit{Minimize}}\ \boldsymbol{B = Vx}$$

$$\textbf{\textit{s.t.}}\ \boldsymbol{Cx \ge Z^*\ , X \ge 0} \qquad (3)$$

Solving problem (3) yields x^*, B^* (= Vx^*) and b^* (= Ax^*). The value $\mathbf{b}^*$ identifies the minimum budget to achieve $\mathbf{Z}^*$ through $\mathbf{x}^*$ and $\mathbf{b}^*$. At $B^* \le B$, the optimal design reached. Since $B^* \ge B$, the optimum-path ratio for achieving the ideal performance $\mathbf{Z}^*$ for a given budget level $\boldsymbol{B}$ is defined as:

$$\boldsymbol{r^* = \frac{B}{B^*}}$$

And establish the optimal system design as **(x, b, Z)**, where $x = r^*x^*$, $b = r^*b^*$ and $Z = r^*Z^*$. The optimum-path ratio $\boldsymbol{r}^*$ provides an effective and fast tool for efficient optimal redesign of large-scale linear systems.

2.1 The optimum-path ratios in De Novo programming

Shi (1995) summarized In this section, based on the basic optimum-path ratio $\boldsymbol{r}^*$, several optimum-path ratios as alternatives for selecting the optimal system designs to solve De Novo programming problems.

Given a De Novo problem (1), we transform it into problem (2), which is a "knapsack" linear program with q criteria. Let $C = (c_j^k)_{q*n}$ be the criteria coefficient matrix, where c_j^k is the coefficient for the j^{th} variable on the k^{th} criterion. Without loss of generality, we assume $c_j^k > 0$, $v_j > 0$ and $B > 0$.

Consider the k^{th} criterion of problem (2) subject to $Vx \leq B$, $x \geq 0$, which is a linear knapsack program. Let $\frac{c_a^k}{V_a} = max_{1\leq j\leq n}\left\{\frac{c_j^k}{V_j}\right\}$ Then, the optimal solution is $x_j^k = \frac{B}{V_a}$, if $j = a$;0, if $j \neq a$. Using x_j^k , we have $b_j^k = Ax_j^k$, and $B_j^k = Vx_j^k$, $k = 1, \dots, q$. Note that b_j^k is the budget level of production x_j^k with respect to the k^{th} criterion. The design (x_j^k, b_j^k, z_k^*) is an optimal system design for a De Novo programming problem with a single criterion. Applying it to problem (1), some optimum-path ratios can be constructed for identifying various optimal system designs.

Given a problem (1), assume $q \leq n$ (i.e., the number of criteria is less than or equal to the number of variables under consideration). Suppose we individually solve k single criterion De Novo programs and obtain solutions $(x_{j1}^1, x_{j2}^2, \dots, x_{jq}^q)$.

Without loss of generality, suppose $(j_1 \leq j_2 \leq \cdots \leq j_q)$. Then, we define $x^{**} = (x_{j1}^1, x_{j2}^2, \dots, x_{jq}^q, 0,0, \dots, 0)$ as a *synthetic optimal solution* from the solutions $(x_{j1}^1, x_{j2}^2, \dots,$ and $x_{jq}^q)$. Thus, we can obtain $b^{**} = Ax^{**}$, $Z^{**} = Cx^{**}$ and $B^{**} = Vx^{**}$. To utilize (x^{**}, b^{**}, Z^{**}) the design in our study, using problem (3), the relationships between the budgets $B^{**}, B^*, B,$ and b_j^k are summarized in the following theorem that serves as the basis of the optimum-path study.

$$\boldsymbol{B^{**} \geq B^* \geq B \geq b_j^k}\textbf{, for } \boldsymbol{k = 1, \dots, q}$$

Since $\sum \gamma_k = 1$, and $0 \leq \gamma_k \leq 1$, this simply follows from $B \geq b_j^k$, for $k = 1, \dots, q$ in the Theorem. By the above Theorem, we can define six types of optimum-path ratios as follows:

(i) $r^1 = \frac{B^*}{B^{**}}$; (ii) $r^2 = \frac{B}{B^{**}}$; (iii) $r^3 = \frac{\sum \gamma_k b_{jk}^k}{B^{**}}$

(iv) $r^4 = \frac{B}{B^*}$; (v) $r^5 = \frac{\sum \gamma_k b_{jk}^k}{B^*}$; (vi) $r^6 = \frac{\sum \gamma_k b_{jk}^k}{B}$

In the above optimum-path ratios, $r^4 = r^*$, which is the basic optimum path ratio studied by Zeleny. The ratio r^1 is the optimum-path ratio for achieving the synthetic-optimum performance Z^{**} related to a given meta-optimum budget level B^*; r^2 is the optimum-path ratio for achieving the synthetic-optimum performance Z^{**} related to a given initial budget level B ; r^3 is the optimum-path ratio for achieving the synthetic-optimum performance Z^{**} related to a given combined budget level $\sum \gamma_k b_j^k$; and r^5 is the optimum-path ratio for achieving the ideal performance Z^* related to a given combined budget level $\sum \gamma_k b_j^k$; and r^6 is the optimum-path ratio for achieving the optimum performance Z^c related to a given combined budget level $\sum \gamma_k b_j^k$. Assume the given initial budget level B in problem (1) or (2) can be replaced by either B^* or $\sim\sum \gamma_k b_j^k$. By using these optimum-path ratios, the following optimal system designs can be established:

(i) $x^1 = r^1 x^{**}$, $b^1 = r^1 b^{**}$, and $Z^1 = r^1 Z^{**}$
(ii) $x^2 = r^2 x^{**}$, $b^2 = r^2 b^{**}$, and $Z^2 = r^2 Z^{**}$
(iii) $x^3 = r^3 x^{**}$, $b^3 = r^3 b^{**}$, and $Z^3 = r^3 Z^{**}$
(iv) $x^4 = r^4 x^{**}$, $b^4 = r^4 b^{**}$, and $Z^4 = r^4 Z^{**}$
(v) $x^5 = r^5 x^{**}$, $b^5 = r^5 b^{**}$, and $Z^5 = r^5 Z^{**}$
(vi) $x^6 = r^6 x^{**}$, $b^6 = r^6 b^{**}$, and $Z^6 = r^6 Z^{\mathrm{nd}}$

The meaning of the above optimal system design$\left(x^{\mathrm{i}}, b^{\mathrm{i}}, Z^{\mathrm{i}}\right)$, $i = 1, \ldots, 6$, is that b^{i} , the optimum portfolio of resources to be acquired at the current market prices, p, allows one to produce x^{i} and realize the multicriteria performance Z^{i}. When problem (1) or (2) is actually applied to solve real world problems, these designs may be presented to the decision maker as candidates for the final optimal system design.

3. A review over De Novo Programming

De Novo Programming for the various optimization problems is presented in this section. At the end of this section, the Analysis & Summary of Literature Review is reached for future works including the fields of each problem and its applications.

Zeleny (1986) introduced a new way of resolving multiple-criteria decision making problems (De Novo programming) to pursue the requirements of modern production which characterized by no-waste, no-buffer, just-in-time operations, full utilization of scarce resources, multiple objectives (quality, worker satisfaction, profits, etc.), and continuous flexibility of design and redesign of systems. Bare and Mendosa (1988) introduced the subject of soft optimization using De Novo programming formulation of single and multiple objective LP optimization techniques which incorporate multiple objectives for increasing the utility of forest planning models. Bare illustrate the potential use of designing optimal forest systems in the face of conflictive objectives. A multiple objective LP model is used to illustrate this approach. Both the generation and evaluation of compromise solution under De Novo conditions are discussed.

Zeleny (1990) explained the purpose of optimizing the system cannot be just to improve the performance of a given, pre-configured system but rather to find the best system configuration itself, i.e., design an optimal system. Zeleny presented a theory and methodology of optimal system design embodied in De Novo programming. Li and Lee (1993) presented an improved approach to solve the general multiple criteria De Novo programming where both the goals and the coefficients are treated simultaneously. Depending on the numerical approach, the resulting problems can be solved either as a linear problem combined with a search routine or as a nonlinear programming problem.

Shi (1994) proposes several optimum-path ratios for enforcing different budget levels of resources so as to find alternative optimal system designs for solving multi-criteria De Novo programming problems. Then, the study of optimum-path ratios is applied to solve an optimal pattern matching problem which is formulated by the De Novo programming with a given initial budget level and an optimal pattern preferred by the decision maker. An interactive algorithm is developed to continuously reshape the problem for matching the optimal pattern. A numerical example is also used to illustrate the algorithm.

Babic and Pavic (1996) presented the possibilities for optimal production plan designing by the application of the De Novo programming approach. Production plan for a real production system is defined taking into account financial constraints and given objective functions. The study illustrated how it is possible to design an optimal production program and to provide its optimal functioning and maintenance. Shi (1999) tried to apply multi-criteria De Novo programming to formulate and solve problems of system design that involve multiple decision makers and a possible debt. In the framework of the system design model, each involved decision maker has his or her own preference for the budget availability level associated with multi-criteria under consideration. If the possible debt occurs in the design time, the model allows flexibility for decision makers to borrow additional money from the bank with a fixed interest rate so as to keep the production process feasible. Zeleny (2000) introduced the two fundamental dimensions to management: what is your system and how do you operate it. One can of course operate a bad system very well or a very good system rather poorly. The main foundation of the competitive advantage already recognized and often achieved, is to operate very good systems very well. Managing the optimally designed, high-productivity, tradeoffs-free systems would undoubtedly return the lost joy, pride and self-confidence into modern business and management. He summarized the basic formalism of De Novo programming, as it applies to linear systems.

Zeleny (2005) draw attention to the impossibility of optimization when crucial variables are given and present eight basic concepts of optimality. He chosen a more realistic problem of linear programming where constraints are not "given" but flexible and to be optimized and objective functions are multiple: De novo programming. Huang *et al.* (2005) proposed an optimal resource portfolio by using the De Novo perspective. A numerical example demonstrated the criteria of strategic alliances. The authors explained the formation of strategic alliances and provided solutions for resource allocation in achieving the desired level. In this situation, the De Novo approach is more suitable than traditional mathematical programming. The most critical problem with the De Novo approach is that the required budget will exceed the subject budget using De Novo programming in some situations. But the alliances can overcome this difficulty. They illustrated that the De Novo perspective provides another view on strategic alliances and gives the optimal resource allocation. Unlike traditional mathematical programming, the De Novo approach does not have the limitation of element independence.

Chen and Hsieh (2006) introduced the De-Novo programming problems by extending to a fuzzy dynamic programming problem. First, a traditional De-Novo programming problem is modified to a De-Novo programming problem with multiple fuzzy goals, fuzzy constraints and multiple stages. Second, he regarded this fuzzy multi-stage De-Novo programming problem as a fuzzy dynamic programming problem, which is identical to a fuzzy multi-objective combinatorial optimization problem.

Babic *et al. (*2006) presented the use of multi-criteria approach in designing the optimal production system. They combined the multiple criteria and De Novo programming in a production model. Moreover, it will be applied in a real production system which produces various ferroalloys using a number of different raw materials. The most favorable solutions in conditions of "variable" constraints will be looked for, benefiting De Novo approach. Lastly, the paper will demonstrate how the usual multi-criteria problems could be handled in a different concept of optimization with De Novo programming approach.

Hung *et al.* (2006) identified the optimal maintenance strategies for a pavement management system (PMS) which is a set of tools or methods that assist decision makers in searching optimal resource allocation and then deciding optimal maintenance strategies for keeping pavements in a serviceable condition over a given period of time. The optimal maintenance strategies was identified by three objectives – maximizing pavement improvement, minimizing the incremental cost during maintenance activities, and maximizing pavement serviceability using De Novo Programming to reallocate maintenance resources and obtain the actual optimal resource allocation model for pavement maintenance sections in Taiwan Area National Freeway Bureau (TANFB) and Taiwan Area National Freeway Bureau (TANFB) based on real data. According to the findings, the direction of resources adjustment and improvement strategies are proposed as well.

Chen *et al.* (2008) introduced a combined De Novo programming with Multiple objective decision making (MODM) techniques to solve resource allocation problems for Environment-watershed resource management (EWRM). They discussed a multi-objective model designed from the De Novo perspective to help environmental-watershed optimize their maintenance resource portfolio, and solve the land used resource problem. The new optimization method, a trade-off-free system, can achieve the ideal value of each objective without adding any budget. They designed an optimal systems rather than simply optimizing the given system for the environment-watershed land used resource management.

Chen *et al.* (2008) explored integrating information technology into instruction to build an education resources allocation planning model using De Novo programming for study. They expected building an efficient planning model of integrating information technology into instruction for school education resources allocation using De Novo programming for achieving aspired/desired level base on education resources allocation of school. They made the system in the set budget for accomplishing the resources allocation with minimum cost. They discovered that school can build a model of optimal education resources allocation planning model with De Novo programming. The efficiency planning model using De Novo programming not only can get the optimal resources allocation but also enhance the performance of teaching activities.

Chen *et al.* (2009) used the De Novo programming approach as a strategic alliance alternative to achieve optimal resource allocation in supply chain systems. He developed an efficient resource planning model for best optimal resource allocation results in an enterprise resource portfolio. The resources in the model optimized the trade-offs with the De Novo programming approach.

Zeleny (2010) in the handbook of multi-criteria analysis explored some topics beyond traditional MCDM. He explained the simplest possible terms what multi-objective optimization is, and defined the subject matter, and discussed the role of tradeoffs-based versus tradeoffs-free thinking.

Fiala (2011) presented approaches for solving the multi objective De novo linear programming (MODNLP) problem, extensions of the problem, examples, and applications.

Fiala (2012) used the De Novo programming as a methodology of optimal system design by reshaping the feasible sets in linear systems. He summarized the basic concepts of the De Novo optimization, and presented extensions, methodological and actual applications. He formulated the supply chain problem, and solved it using the De Novo programming approach.

Kasprzyk *et al.* (2012) demonstrated a new interactive framework for sensitivity-informed de Novo planning to confront the deep uncertainty within water management problems. The framework couples global sensitivity analysis using Sobol variance decomposition with multi-objective evolutionary algorithms (MOEAs) to generate planning alternatives. They explored these issues within the context of a risk-based water supply management problem, where a city seeks the most efficient use of a water market. The study examined a single city's water supply in the Lower Rio Grande Valley (LRGV) in Texas, using 6 objectives problem formulations that have increasing decision complexity for both a 10 years planning horizon and an extreme single-year drought scenario. The de Novo planning framework illustrated how to adaptively improve the value and robustness of the problem formulations. Hung *et al.* (2013) used multi-objectives goal programming to solving priority with the pavement maintenance works in the pavement management system. The De Novo Method used to approach the ideal point. They tried to use this method to solve Taiwan Freeway's maintenance work programming. The analytical results completed by De Novo programming, the performance improved by budget. So de novo programming apply to pavement maintenance can give a new way to solve the problem.

Chakraborty and Bhattacharya (2013) presented a new approach of applying De-Novo programming technique for optimal design of a system. The applicability of the method has been illustrated through examples. It is believed that the solution procedure presented here could be implemented in the solution of other derivatives and extension of De-Novo programming. The advantage of the proposed approach is that it requires less number of variables (only slack variables) to be introduced in the solution procedure and thus reducing the processing time in comparison with the existing method.

Umarusman (2013) suggested De Novo Programming and Min-max Goal Programming approaches and used positive and negative ideals. He explained the Problem-solving phases of the model through illustrative examples. He said that De Novo Programming does not have its unique general solution algorithm. Especially when multi-objective problems are discussed in the light of De Novo hypothesis, the solving method directs decision maker to different solutions. He identified compromise solutions of De Novo programming problems with the use of min-max approach, compromise programming yield important results in preliminary examination conducted by his study. Especially when relative weights are equally important for both Goal Programming and Compromise Programming, obtained solution yields the same results as Zimmermann's fuzzy approach in terms of distance function model. On the other hand, if relative importance is different, more efficient results can be achieved.

Umarusman and Türkmen (2013) introduced brief history of De Novo technique, mathematical definitions of Multi-criteria De Novo Programming, and Global Criterion Method is given with their respective principles. They showed a real firm application where the problem and solution parts are shown. They explained budget given for the same level of production is significantly reduced by an improvement in problem constraints. It can be seen that both Global Criterion Method and simple De Novo solutions give the same values. Optimum solution occurs in first two objective functions for both methods, which results to return of the same value in final calculations. They were aiming to continue studying multi criteria De Novo Programming with and without under Global Criterion Method in future. Tezenji *et al.* (2017) proposed a bi-objective integrated model for supplier location-allocation, capacity allocation and supplier selection, and order allocation problems in two level supply chains. There are five goals of the proposed model. In the first step they proposed a single-objective model to minimize the total costs. In the second stage they used De Novo programming to determine the optimal capacity of selected supplier(s). They used NRGA and NSGA-II algorithms to solve the proposed bi-objective mix-integer nonlinear model. At the end, they proposed various test problems to show the performance of the proposed methodology. Bhattacharya and Chakraborty (2018) presented an alternative approach forthe solution of the general multi-objective De Novo Programming Problem under fuzzy environment in one step using Luhandjula's compensatory $\boldsymbol{\mu_\theta}$-operator. Also the solution obtained by the proposed approach represents an efficient solution of the problem considered under the assumption of the uniqueness of the solution. The method has been illustrated by a numerical example. They showed that this methodology requires less processing time in comparison with the existing ones because through the proposed method, the general MODNPP can be solved in one step only. To make the problem more flexible, instead of crisp coefficients, fuzzy, type2 fuzzy coefficients can be considered and solution procedure can be investigated.

Zhuang and Hocine (2018) explored the potential use of the meta-goal programing approach (meta-GP) for solving multi-criteria De Novo programing problems. Methodologically, the objectives of the De Novo programing problem are converted into meta-goals during formulation to arrive at the most satisfactory decision in the multi-objective decision-making context. This approach is shown superior to the conventional 'multi- criteria solution procedure' for the De Novo programing problem, in that it provides decision-makers with more flexibility in expressing their preferences, by merging the original explicit goals as meta-goals. The proposed model is to a decision case in identifying the best plan for the exploitation of wind energy sourcing is provided, illustrating the effectiveness of the proposed novel solution approach.

4. Analysis & Summary of the Literature Review

Table 1 Summary of the Literature Review

No.	Title	Author(s)	Application	Method
1	optimal system design with multiple criteria: De Novo programming approach	Zeleny (1986)	Production system.	Applying a New concept of optimality, new way of resolving MCDM conflicts, and new conditions for optimal and continuous system improvement.
2	A soft optimization approach to forest land management planning.	Bare and Mendosa (1988)	Forest planning model.	They introduced the subject of soft optimization using De Novo programming formulation of single and multiple objective LP optimization techniques.
3	Optimizing given systems vs. designing optimal systems: The	Zeleny (1990)	Numerical example.	A theory and methodology of optimal system design embodied in De Novo

No.	Title	Author(s)	Application	Method
	De Novo programming approach.			programming.
4	De Novo programming with fuzzy coefficients and multiple fuzzy goals.	Li and Lee (1993)	Numerical approach.	They solved the general multiple criteria De Novo programming problem where both the goals and the coefficients are treated simultaneously.
5	Studies on optimum-path ratios in multi criteria De Novo programming problems.	Shi (1994)	Numerical example.	He proposed several optimum-path ratios for enforcing different budget levels of resources so as to find alternative optimal system designs for solving multi-criteria De Novo programming problems.
6	Multicriterial production planning by De Novo programming approach	Babic and Pavic (1996)	Production program.	Presented the possibilities for optimal production plan designing by the application of the De Novo programming approach.
7	Optimal system design with multiple decision makers and possible debt: A multi criteria de Novo programming approach.	Shi (1999)	Budget availability and possible debt.	He made the framework of the system design model using a multi criteria de Novo programming approach.
8	The elimination of tradeoffs in modern business and economics.	Zeleny (2000)	Production system.	He summarized the basic formalism of De Novo programming, as it applies to linear systems.
9	The evolution of optimality: de novo programming.	Zeleny (2005)	Numerical example.	He drawn attention to the impossibility of optimization when variables are given and present eight basic concepts of optimality including De Novo programming.
10	Motivation and resource-allocation for strategic alliances through the De Novo perspective.	Huang *et al.* (2005)	Strategic alliances (numerical example)	They provided an optimal resource portfolio by using the De Novo perspective in strategic alliances and provided solutions for resource allocation.
11	Fuzzy multi-stage De-Novo programming problem.	Chen and Hsieh (2006)	Fuzzy dynamic programming problem (numerical example)	They extended the traditional De-Novo programming problem to a De-Novo programming problem with multiple fuzzy goals, fuzzy constraints and multiple stages. Then, they regarded this fuzzy multi-stage De-Novo programming problem as a fuzzy dynamic programming problem.
12	Optimal System Design with Multi-	Babic *et al.* (2006)	Production system.	They combined the multiple criteria and De Novo programming in a production model

No.	Title	Author(s)	Application	Method
	criteria Approach.			to design the optimal production system.
13	Optimal resource allocation model for pavement maintenance established by de novo programming method.	Hung *et al.* (2006)	Pavement maintenance in Taiwan Area National Freeway Bureau and Taiwan Area National Freeway.	They identified the optimal maintenance strategies for a pavement management system using the De Novo Programming to reallocate maintenance resources and obtain the actual optimal resource allocation model.
14	Fuzzy Multiple Criteria Decision Making Approach for Environment Watershed.	Chen *et al.* (2008)	Watershed resource management maintenance.	They introduced a combined De Novo programming with Multiple objective decision making (MODM) techniques to solve resource allocation problems for Environment-watershed resource management (EWRM).
15	Build an education resources allocation planning model of school with integrating Information Technology.	Chen *et al.* (2008)	An education resources allocation of school.	They built an education resources allocation planning model using De Novo programming for school by integrating information technology into instruction to achieve the aspired/desired level.
16	Perspective strategic alliances and resource allocation in supply chain systems through the De Novo programming approach.	Chen *et al.* (2009)	Taiwanese IC-design service firms.	They used the De Novo programming approach as a strategic alliance alternative to achieve optimal resource allocation in supply chain systems. He developed an efficient resource planning model for best optimal resource allocation.
17	Multi objective optimization, systems design and de novo programming.	Zeleny (2010)	Numerical example.	He explained the simplest possible terms what multi objective optimization is, defined the subject matter, and discussed the role of tradeoffs-based versus tradeoffs-free thinking using De Novo programming.
18	Multi objective De Novo Linear Programming.	Fiala (2011)	Illustrative example.	He presented approaches for solving the multi objective De novo linear programming (MODNLP) problem, extensions of the problem, examples, and applications.
19	Design of Optimal Linear Systems by Multiple Objectives.	Fiala (2012)	Numerical example.	He used De Novo programming as a methodology of optimal system design by reshaping the feasible set in linear systems. He formulated the supply chain problem, and solved it using De Novo programming approach.
20	Many-objective de	Kasprzyk *et*	Single city	They demonstrated a new interactive

No.	Title	Author(s)	Application	Method
	Novo water supply portfolio planning under deep uncertainty.	***al.* (2012)**	**water supply in the Lower Rio Grande Valley (LRGV) in Texas.**	**framework for sensitivity-informed de Novo planning to confront the deep uncertainty within water management problems by coupling global sensitivity analysis using Sobol' variance decomposition with multi-objective evolutionary algorithms (MOEAs).**
21	**Apply De Novo Programming in Pavement Maintenance Strategy Optimization.**	**Hung *et al.* (2013)**	**Taiwan Freeway's maintenance work system.**	**They used multi-objectives goal programming to solve priority with the pavement maintenance works in the pavement management system using the De Novo method to approach the ideal point.**
22	**Optimal System Design under Multi-Objective Decision making using De-Novo Concept: A New Approach.**	**Chakraborty and Bhattacharya (2013)**	**Numerical example.**	**Presented a new approach of applying De-Novo programming technique for optimal design of a system. The advantage of the proposed approach is that it requires less number of variables, thus reducing the processing time.**
23	**Min-Max Goal Programming Approach For Solving Multi-Objective De Novo Programming Problems.**	**Umarusman (2013)**	**Numerical example.**	**He suggested De Novo Programming and Min-max Goal Programming approaches using positive and negative ideals. He identified compromise solutions using min-max approach, compromise programming yield important results.**
24	**Building Optimum Production Settings using De Novo Programming with Global Criterion Method.**	**Umarusman and Türkmen (2013)**	**A production system that produces four types of plastic balls**	**Global Criterion Method was given with their respective principles using De Novo programming. It was seen that both Global Criterion Method and De Novo solutions give the same values.**
25	**Bi-objective location-allocation-inventory-network design in a two-echelon supply chain using de novo programming, NSGA-II and NRGA.**	**Tezenji *et al.* (2017)**	**Bi-objective location allocation inventory network.**	**They proposed In the first stage a single-objective model to minimize the total costs. In the second stage they used De Novo programming to determine the optimal capacity of selected supplier(s). They used NRGA and NSGA-II algorithms to solve the proposed bi-objective mix-integer nonlinear model.**
26	**Solution of the general multi-objective De-Novo programming problem using compensatory operator under fuzzy environment.**	**Bhattacharya and Chakraborty (2018)**	**Numerical example.**	**They presented an alternative approach for the solution of the general multi-objective De Novo Programming Problem under fuzzy environment in one step using Luhandjula's compensatory μ_θ–operator to solve the general multi-objective De Novo Programming Problem.**
27	**Meta goal programing approach for solving multi-criteria de Novo**	**Zhuang and Hocine (2018)**	**Install (build) wind (energy) farm (sites)**	**They explored the potential use of the meta-goal programing approach (meta-GP) for solving multi-criteria De Novo**

No.	Title	Author(s)	Application	Method
	programing problem.		for the Algerian government.	programing problems. Methodologically, the objectives of the De Novo programing problem are converted into meta-goals during formulation, to arrive at the most satisfactory decision in the multi-objective decision-making context.

Table 2 The number citations according to the Journal or sources

No.	Source	Citations
1	Engineering costs and production economics	1
2	International journal of general systems	1
3	Canadian journal of forest research	1
4	Journal of mathematical analysis and applications	1
5	Pergamon	1
6	International Journal of Operations Research	2
7	New Frontiers of Decision Making for the Information Technology Era	1
8	International Conference on Evolutionary Multi-Criterion Optimization	1
9	ELSEVIER	5
10	Global Business@ Economics Anthology	1
11	Joint international conference on computing and decision making in civil and building engineering	1
12	Advanced Materials Research	1
13	Industrial Engineering and Engineering Management	1
14	International Journal of Sustainable Strategic Management	1
15	Handbook of Multicriteria Analysis, ed: Springer	1
16	Acta Universitatis Palackianae Olomucensis. Facultas Rerum Naturalium. Mathematica	1
17	Multiple Criteria Decision Making/University of Economics in Katowice	1
18	Environmental Modelling & Software	1
19	International Journal of Computer Applications	1
20	International Journal of Logistics Systems and Management	1
21	Journal of Physics: Conference Series	1
Total number of citations		27

From the Analysis of the Literature Review, the De Novo programming is a good field for building the optimal system design. Figure 1 represents the applications on the De Novo programming technique, it has been shown that (DNP) applications used as follows:

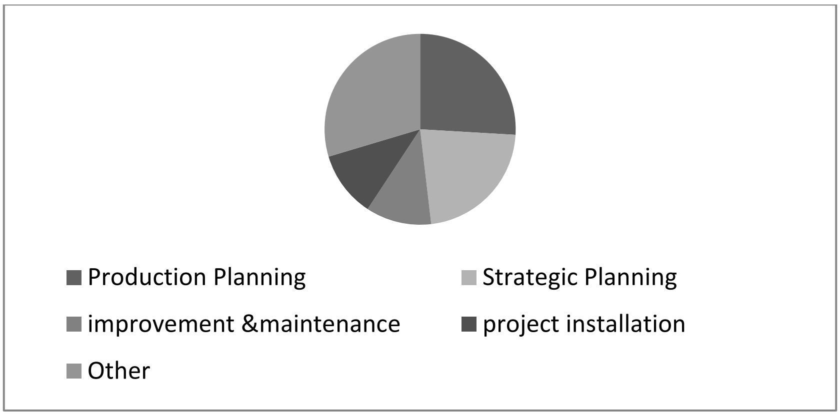

Figure 1 The percentage of applications of De Novo Programming on different areas

26% of the applications used in production planning to find the optimum resource portfolio for different type of products (Plastic balls, wood utilization, ferroalloys, clothes, hardware, software, and health care), 22% used in Strategic planning (strategic alliances, funding, supply chains, and inventory design), 11% used in improvement & maintenance (pavement maintenance, Freeway's maintenance, and watershed resource maintenance), 11% used in project installation (installing wind energy farm, water supply portfolio, and building an education system), and 30% on other type of applications

The De Novo programming approach made a new evolution for the concept of optimality. This technique is more helpful for the decision maker to allocate the optimum resource portfolio specially while having tradeoffs between the objectives of the multi criteria decision making problems to meet the ideal point of the solution which is frequently outside the feasible set of solution. The most critical problem with the De Novo approach is that the required budget could exceed the subject budget using the De Novo programming, so that the optimum path ratio in some situations is used to avoid the raised level of the required budget related to the available one.

5. Conclusion:

The De Novo programming is a technique which uses to redesign a system reaching to optimal solution. The objective is not simply to optimize a given system, but to design an optimal system. De Novo programming can deal with single or multiple criteria optimization problems. A brief review of De Novo programming is presented in this paper, then Analysis and Summary of the Literature Review. Applications of De Novo programming for various optimization problems also discussed.

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A simulated model of sprinklers irrigation systems

Naglaa Ragaa Saeid Hassan(1) and Ahmed Al Sayed Mohammed Shahin (2)

Abstract

Center pivot irrigation is a form of overhead sprinkler irrigation consisting of several segments of pipe (usually galvanized steel or aluminum) with sprinklers positioned along their length, joined together and supported by trusses, and mounted on wheeled towers. The machine moves in a circular pattern and is fed with water from the pivot point at the center of the circle. The sprinkler flow rate out of each sprinkler orifice is based on the water pressure supplied to the sprinkler inlet. The objective of this paper is to build a simulated model **of center pivot irrigation** to optimize the performance of system by estimating the expected number of a sprinkler and diameter of nozzle.

Keywords: Surface irrigation, Irrigation districts, Water management, Reservoir management

1. Introduction

Water is the main yield-determining factor in the majority of agricultural systems. Irrigation systems help growers manage weather related risks by effectively supplementing rainfall (Perry et al. 2002). To sustain agricultural production in the coming years, it is important to optimize irrigation systems, adjusting water application to crop water requirements. This will help protect both the quantitative and qualitative aspects of water conservation.

Center pivot irrigation is a form of overhead sprinkler irrigation consisting of several segments of pipe (usually galvanized steel or aluminum) with sprinklers positioned along their length, joined together and supported by trusses, and mounted on wheeled towers. The machine moves in a circular pattern and is fed with water from the pivot point at the center of the circle. The system is in use, for example, in parts of the United States, Australia, New Zealand, and Brazil and also in desert areas such as the Sahara and the Middle East. Center pivots are typically less than 1600 feet (500 meters) in length (circle radius) with the most common size being the standard 1/4 mile (400 m) machine. A typical 1/4 mile radius crop circle covers about 125 acres of land. To achieve uniform application, center pivots require an even emitter flow rate across the radius of the machine. Since the outer-most spans (or towers) travel farther in a given time period than the innermost spans, nozzle sizes are smallest at the inner spans and increase with distance from the pivot point.

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Aerial views show fields of circles created by the watery tracings of "quarter- or half-mile of the center-pivot irrigation pipe, created by center pivot irrigators which use "hundreds and sometimes thousands of gallons a minute.

The advantages of center pivot and lateral move systems are:

- **Precise application:** The systems are able to apply a prescribed volume of water to match crop water requirements. It reduces the opportunity for surface runoff or deep percolation if the system is designed to match soil infiltration characteristics.
- **Reduced variability:** The reported application efficiencies for new well designed machines are generally in the 80-95% range, compared to 50-90% for surface irrigation systems.
- **Lower labor requirements:** The labor's requirements are generally lower than surface irrigation but it depends on the system and\ or the degree of automation of the machine.
- **Opportunities for fertigation:** Fertigation allows the targeted application of small quantities of nutrients, with a reasonable uniformity of application and less risk of nutrient losses. The irrigation system may also be used to apply herbicides and pesticides.
- **Less land forming:** The system can work on rolling topography. However, there might be a need for some land forming for surface drainage or rainfall induced runoff. The sprinkler flow rate out of each sprinkler orifice is based on the water Pressure supplied to the sprinkler inlet. See (Fig 1 : 4)

Fig 1 Vertical View For center pivot irrigation

Fig 2 Engineering Drawing of Pivot

Fig 3 Pump and center of pivot

Fig 4 Towers of Pivot & sprinkler

Hager, (2006) define operation research (OR) as the discipline that helps us in decision making which is based upon the information technology. The main objective of OR is to utilize limited resource for more benefits. Simulation models where decision makers want to develop simulators to look for improvement and to test and establish bottom line for the improvement idea that are being made. Simulation models linked to decision support systems for the management of irrigated areas constitute powerful tools to achieve these goals (FAO, 1994; Hall, 1999; Walker, 1999; Playán et al., 2000).

In the last decades, the development of such models has been boosted by developments in computer science and the widespread use of personal computers. Different approaches have been used to simulate the processes characterizing an irrigated area. In this paper, the center pivot simulation model is used to improve the design of new systems and to modify existing systems with the view of improving irrigation performance. The objective of this paper is to build a simulated model **of center pivot irrigation** to optimize the performance of system by estimating the expected number of a sprinkler and diameter of nozzle. This paper is organized as follows: Section 2 presents "**Research Optimization Techniques in Irrigation**". Section 3 considers "**Methodology**" which explains **steps of building the simulation model** and figure about suggested irrigation model. Section 4 introduces "**The details of proposed computerized irrigation simulation model**" which explain the details about the input, processing and output units and finally Section 5 presents "Conclusion and future work".

2. Research Optimization Techniques in Irrigation:

Centre pivot simulation models have been used to improve the design of new systems and to modify existing systems with the view of improving irrigation performance. The simulation of center pivot performance has been the subject of a series of research efforts since the 1960s. Bittinger and Logenbaugh (1962) simulated precipitation under center pivots with the objective of defining the optimal sprinkler spacing in order to obtain uniform water distribution. They developed an analytical model of precipitation under a sprinkler assuming that its water application pattern was either triangular or elliptical. The model was based on the additional hypotheses of continuous movement and linear or circular sprinkler trajectory. They estimated the irrigation depth by moving the water application pattern at the same velocity of sprinkler movement on the pivot lateral. Heermann and Hein (1968) continue this line of research by taking into account the overlapping effect of neighboring sprinklers, and introduced the uniformity coefficient that bears their name. This led to the introduction of the CPED (center pivot evaluation and design) software package (Heermann and Stahl, 2004). CPED input data included sprinkler positions on the lateral, discharge, radial application pattern and time of system revolution. Babel et al. (2005) develop a model for optimal allocation of water to competing demands using two optimization techniques, i.e. weighting technique (WT) and simultaneous compromise constraint (SICCON) technique. The develop model was found capable of allocating water among six sectors with maximizing either satisfaction or net economic return or both.

In other cases, the organizational and social aspects of an irrigated area have been modeled together with the production techniques, in order to model farmers' water use. Applying new technologies to irrigation water management leads to improvements in the productivity and sustainability of agricultural systems. Ines, et al, 2006, conduct an interesting study by combining remote sensing simulation model and GA to discover water management option in irrigated agriculture. Results show that adjusting sowing date and distribution with deficit irrigation, can improve regional yield.

Bagher and Payman, 2009, use GA for optimizing water delivery program. They found that GA is useful for water distribution problem in irrigation channels. Schutze et al, 2009, employed evolutionary optimization technique to find a near optimal solution of the global optimization problem within reasonable computational time. The results so obtained were compared with complex evolution algorithm, optimization algorithm, simulated annealing and differential evolution. The new tool developed shows striking superiority over the existing optimization techniques. Pais, et al, 2010, conduct a study to optimize cost of drip irrigation system using GA. The results show that there in improvement in the calculation runtime and in cost of drip system, as compared to other models available. Tranetal, 2011, develop a model based on dynamic optimization model for managing and optimizing multiple resources for irrigation and fisheries

Mtolera, et al, (2014) develop an algorithm using a particle swarm optimization technique to optimize irrigation tree pipe networks layout and size. A result obtained is compared to the non-optimized method and GA. They observed a quick response from their model with an increase in search space as compared GA. Yoo, et al, (2014) apply Harmony search optimization technique for identifying optimal pipe size in looped irrigation water supply system. The main aim of the research is to develop an algorithm and program to find out the optimal and cost-effective pipe diameter for a looped irrigation system. The algorithm developed can be applied to real life problems and it is more promising than others available models.

3. Methodology "Simulation Model"

Simulation is one of the most widely used operations research and management science techniques, if not the most widely used. A simulation is the imitation of the operation of a real-world process or system over time. Simulation involves the generation of an artificial history of a system and the observation of that artificial history to draw inferences concerning the operating characteristics of the real system. Simulation does not usually provide a recommended decision as does an Optimization model; it provides operating statistics. A primary benefit of simulation analysis is that it enables us to experiment with the model.

3.1 Steps building the Simulation model

- **Problem Definition**

Optimal rationalization of water resources through the identification location of sprinklers along the irrigation system according to specific factors and inputs such as the amount of water, pressure and land area through the design of a computer system

- **Project Planning**

Before developing a simulation, we identify what is to be simulated, the degree of simulation fidelity required, and how the resulting data will be used. Many additional details must be addressed as well. There must be a simulation software development process that deals with issues such as determination of the optimal distribution of the location of the sprinklers length pivot through the design of a computer system for that the simulation is to be operated, including the definition of input data sets, and how simulation output data is analyzed and used as input for a sprinklers programming.

- **System Definition**

After completion of the simulation, the main purpose of the system is to avoid the installation of sprinklers at fault locations along the pivot where the locations of these sprinklers are determined according to specific criteria in the form of mathematical and physical equations.

- **Model Formulation**

This is the stage in the modeling process where we creates a mathematical equations representation of a conceptual model Is consistent with the problem under study where these equations were formulated in the code of the system in which we have been designed for this purpose.

- **Input Data Collection & Analysis**

There is no doubt that The main source of data in this field is the agricultural companies where we collected the data from the specialists and were analyzed and indexed by nature and priority use to obtain the required outputs.

- **Model Translation**

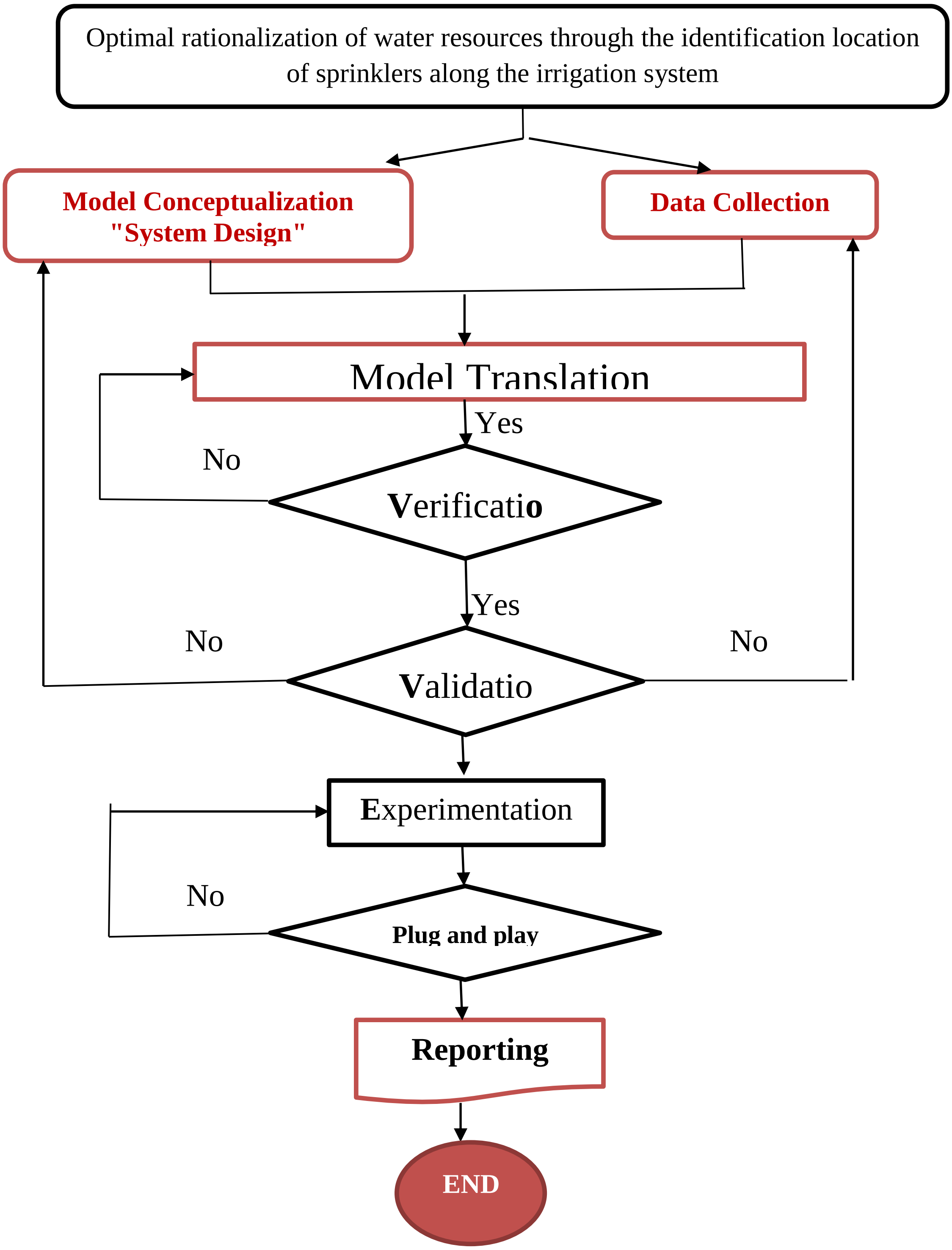
Both the input and output of the simulator were designed in the input screens and output screens that the user can easily handle during the input and get information from the system.

- **Verification & Validation**

At this stage, the results and outputs are tested step-by-step to ensure their validity and compliance with the actual outputs of other systems.

- **Experimentation**

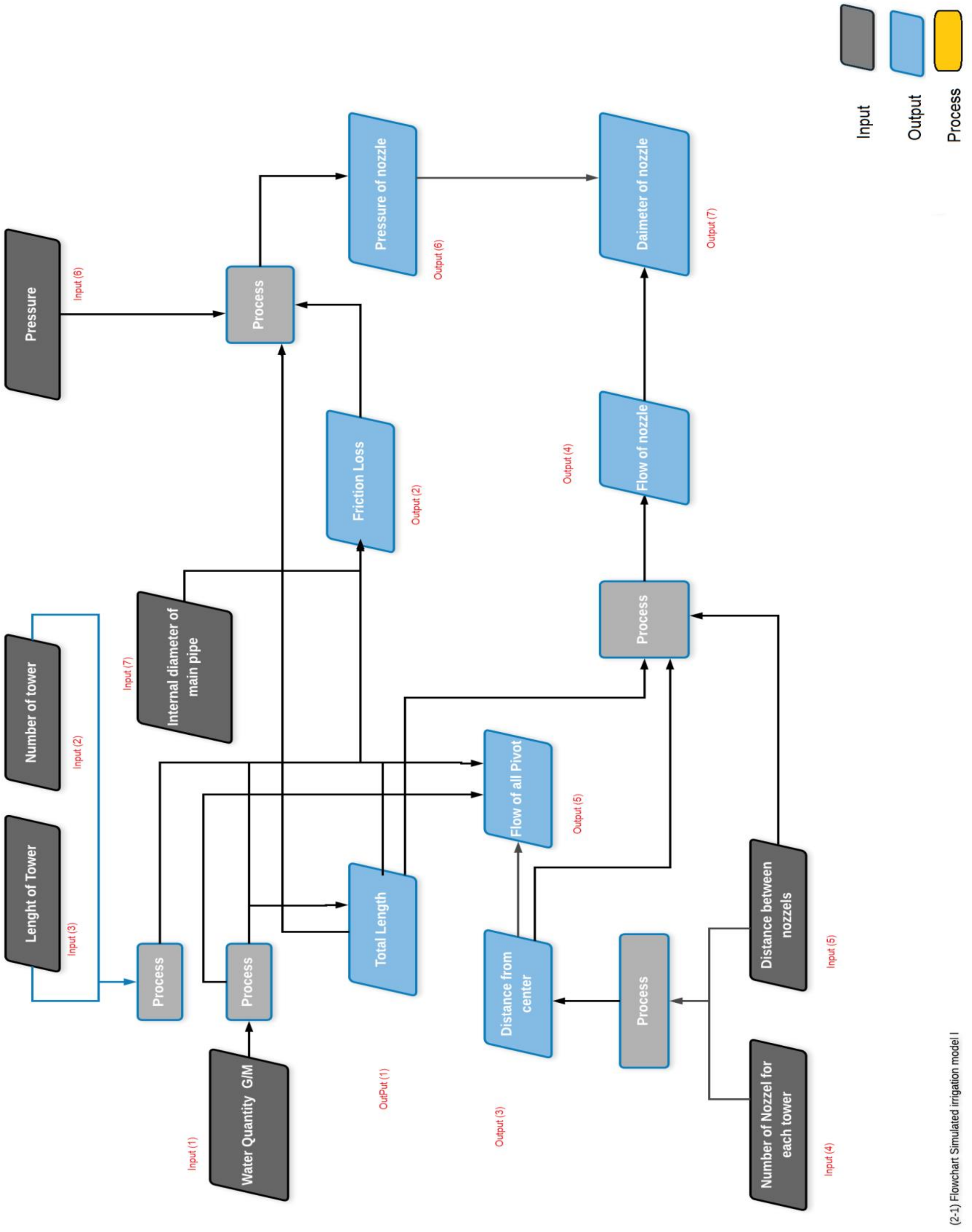
The outputs were validated and matched with the systems already implemented in some companies. Our system has been implemented in many agricultural companies



Flowchart 1 The suggested Simulated model for system Irrigation

4. The details of proposed computerized irrigation simulation model

- Data flow and processing



Flow chart 2 Details about Simulation irrigation model

Inputs:

- The Quantity of water coming out of the well Gallon/Min.
- The number of towers of pivot.
- Tower length in meters.
- The number of nozzles contained in the tower.
- The distance between all the nozzles.
- Internal Diameter Mm
- Pressure at the ending of the flow of water from the well "Last nozzle".

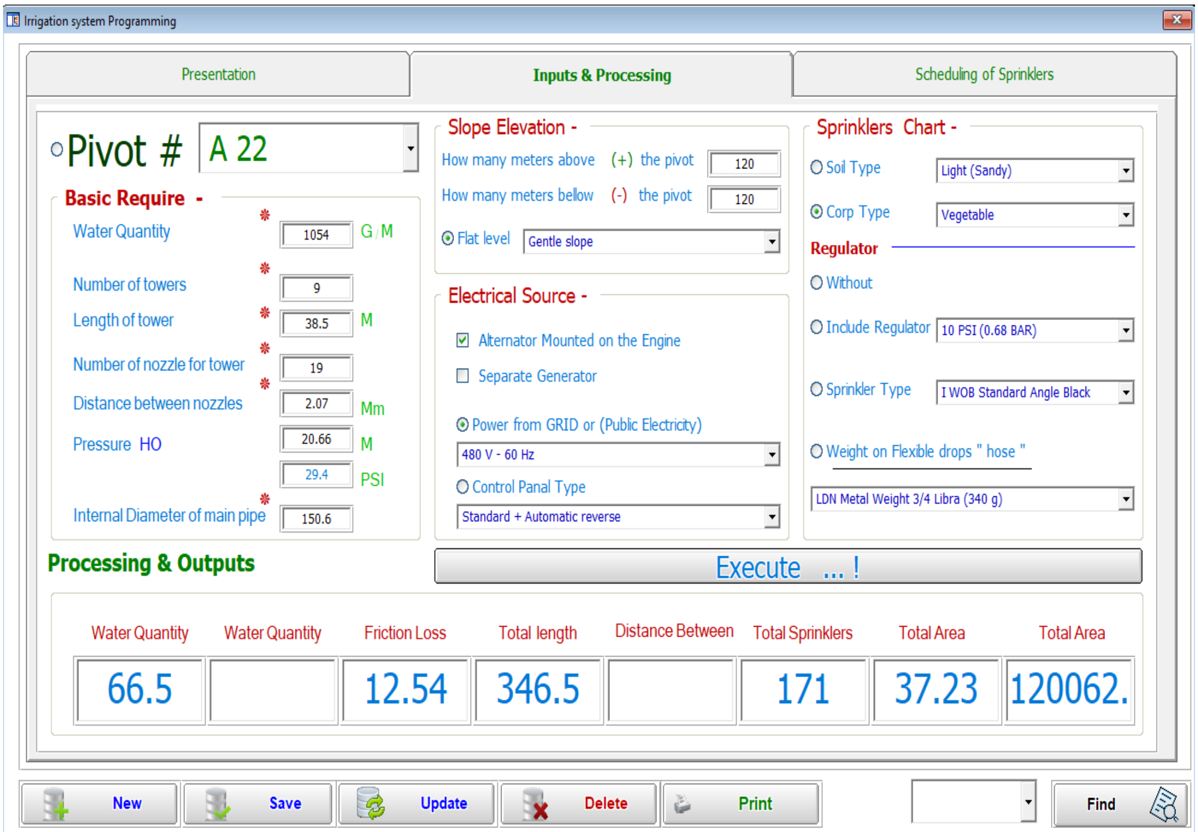


Fig 5 Inputs Screen

In this screen the user enters the data we referred to it before and save it as temporary in memory to go the second step in the system is to process this data to get the information.

Processing:

After the completion of the first step of data entry and temporary storage is called to be processed by inserting them in mathematical and physical equations as we will explain later as a detailed for each one.

Water Quantity: The user can enter the data about the amount of water out from the pump with unit gallon per minute for the system to be converted to another unit, a liter per second to match the mathematical equations carried out by the system, On the other level, it is converted to a gallon unit per minute per hectare to determine the total amount of water per hectare.

Water Quantity L/Sec = Water quantity G/M ÷(15.85)

Water Quantity G/M/Hectare = Water quantity G/M ÷Total Area / Hectare

Friction Loss

This can be calculated by the physics equation

(Hazen-Williams Equation - calculating Head Loss in Water Pipes)

Total towers length

Total length of towers = Number of towers * Length of tower

Total nozzles

Total nozzle = Number of nozzle for tower * Number of towers

Total Distance between nozzles

Total Distance between nozzles **=** Distance between nozzles * Total nozzles

Total Area / Hectare

Total Area / Hectare =

= (((Total length of towers ^ 2) * 3.14) / 10000) - (((38.5 ^ 2) * 3.14) / 10000)

Total area per square meters

Total area per square meters = (Total length of towers ^ 2)

Outputs:

Nozzle #	Distance From Center	Flow Of Nozzle	Flow Of All Pivot	Pressure Of Nozzle	Diameter Of Nozzle
1	2.07	0.005	66.498	33.06	2
2	4.14	0.009	66.491	32.92	2
3	6.21	0.014	66.479	32.78	3
4	8.28	0.019	66.462	32.64	3
5	10.35	0.024	66.441	32.5	4
6	12.42	0.028	66.415	32.35	4
7	14.49	0.033	66.384	32.21	4
8	16.56	0.038	66.348	32.07	5
9	18.63	0.043	66.308	31.93	5
10	20.7	0.047	66.263	31.79	5
11	22.77	0.052	66.213	31.65	5
12	24.84	0.057	66.158	31.51	6
13	26.91	0.062	66.099	31.37	6
14	28.98	0.066	66.035	31.23	6
15	31.05	0.071	65.966	31.1	6
16	33.12	0.076	65.892	30.96	6
17	35.19	0.081	65.814	30.82	7
18	37.26	0.085	65.731	30.68	7
19	39.33	0.09	65.643	30.54	7
20	41.4	0.095	65.551	30.43	7
21	43.47	0.1	65.453	30.29	7
22	45.54	0.104	65.351	30.15	8
23	47.61	0.109	65.245	30.02	8

Fig 6 Outputs screen and scheduling nozzles

The outputs include two kinds of information **(The illustrated figures & the results needed) as follows:**

A) The overall figures such as:

- A Total area of pivot /Hectare.
- A Total number of nozzles to be added to the pivot.
- The Total length of pivot towers.
- Water quantity liter/sec.
- Quantity of water Gallon/Meter /Hectare.

B) As for specifically

- The distance between each one of the nozzles from the center
- The quantity of water flowing from each one of the nozzles
- The Quantity of water flowing to the pivot at the circle
- Water pressure in the mother tube at each one of nozzle
- The last and most important is the size of the nozzles "Diameter nozzles"

Analysis & results:

Column #1 Nozzle number

It is a number generated from an iterative loop that is repeated by the number of nozzles distributed over the total length of the towers.

Column #2 Distance between Nozzles

It is **given** and is determined based on the design of the hub manufacturer.

Column #3 Distance from Center

It is a computation of the distances between the nozzles and the distance from the center.

Column #4 Flow of Nozzle

The flow of nozzle is calculated through the following equations:

(2 * Distance from Center * Distance between Nozzle * Water Quantity) ÷ (Total area per square meters)

Column #5 Flow of All Pivots

It is calculated through the following equation:

(Water Quantity * (1 - (Distance from Center) ^ 2) ÷ (Total area per square meters)

Column #6 Pressure of Nozzle / m

It is calculated through the equations depends on Previous steps.

Column #7 Diameter of Nozzle

The type of nozzle depends on the diameter of nozzles according to their manufacturers

A Real Example:

Table 1 the kinds of diameter of nozzles according to their manufacturers

Nozzle No	**Diameter of Nozzle**
1	**2**
2	**2**
3	**3**
170	**23**
171	**23**

Table 2 The inputs and outputs of real example

#	**Input**	**Data**
1	Water Quantity G/M	1054
2	Number of towers	9
3	Length of tower	38.5
4	Number of nozzle for tower	19
5	Distance between nozzles	2.07
6	Pressure HO	20.66
7	Internal Diameter of mother pipe M/M	150.6
#	**Output**	**Info**
1	Water Quantity L / Sec	66.5
2	Water Quantity G/M/Hec	28.31
3	Friction Loss HF	12.54

So, the Table 2 shows that when the water quantity for example 1054 G/M , the No. of towers = 9 ….and ….so on Then, the water quantity will be 66.5 L/sec.

5. Conclusions and future work

Improper installation of sprinklers in an unsuitable location causes damage to crops and wastewater resources, also the flexibility of the system where we can program different types of tower segments and this is what has been added recently. This paper considers a central pivot simulator model to improve system performance through optimum distribution of sprinklers locations along the pivot.

Future work will be about the central control of the pivot through the control panel connected to the system receives commands to turn on and off the pivot**.**

Acknowledgment

Special thanks to my dear friend Eng. **Mohamed Ashour** for his efforts in helping me**.**

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Queueing System with Priority for Some Customers Case Study: National Bank of Egypt

Faten Mohamed Ali Suliman (1)

Abstract

This study investigates comparative study between performance measures of the queueing system without and with priority with application on the National Bank of Egypt- Zagazig Branch, using daily data for customer access and the rate of service performance during the period of July 2 until August 8 in 2014. This study is used this phenomenon and program of QM for windows. The applied study found that the average length of the class of priority, and also the average service time are less than them in the case of priority by almost half.

Keywords: Queueing System, service performance, Priority service

1. Introduction

The customers have defined the queue as where they wait before being served. A queue is characterized by the maximum permissible number of customers that it can contain. Queues are called infinite or finite, according to whether this number is infinite or finite. Queueing System are often analyzed by analytical methods or simulation. The later technique is a general of wide applications able to incorporate many complexities of a model, but its main drawback is the potentially high development and computational cost to obtain accurate results [Bejan (2007)].

The use of priority-discipline models often provides a very welcome refinement over the more usual queueing models. Many real queueing systems fit these priority-discipline models much more closely than other available models. Rush jobs are taken ahead of other jobs, and important customers may be given precedence over others. Therefore,

The distinction between the two models is whether the priorities are non - preemptive or preemptive. With non-preemptive priorities**,** a customer being served cannot be ejected back into the queue (preempted) if a higher priority customer enters the queueing system. Therefore, once a server has begun serving a customer, the service must be completed without interruption [Pardo and Fuente (2007)]. With preemptive priorities**,** the lowest-priority customer being served is preempted (ejected back into the queue) whenever a higher-priority customer enters the queueing system. A server is there by freed to begin serving the new arrival immediately.

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The Egyptian Governmental Banks play an important role in the stability of the Egyptian economy. But recently, many leading foreign banks have been established in Egypt. To be able to compete with these leading banks, the Egyptian Governmental Banks have to improve their performance efficiency and to present a high quality service. The customers dealing with some departments' service at Zagazig Branch of National Bank of Egypt suffer and complain from the long times they spend in the bank to acquire specific their needed service. This happens especially in specific days in each month and specific days in each week [Mohamed (2008)]. This paper aims to provide suggestion that may help decreasing the time spent to get served. This paper is organized as follows: Section 2 presents "**Literature review**". Section 3 discusses "**Methodology**". Section 4 introduces the "**Case study and empirical results**". Finally, section 5 presents "**Conclusion**".

2. Literature Review

Sarhangian, (2011) has discussed first study for delay system with different classes of impatient customers. He analyzed the M/G1/1+M queue serving two priority classes under the static non-preemptive priority discipline. He also studied the multi–server priority queue considering two cases depending on the time to abandon distribution begin exponentially distribution or deterministic. In all models, he obtained the Laplace transforms of the virtual waiting time for each class by exploiting the level of crossing methods. He derived the steady-state system performance measure. He considered in the second part of the steady-state waiting time distributions of a two class M/G1/1 queue operating under a dynamic priority discipline. He found an accurate approximation for the steady-state waiting time distribution of low- priority customers and he also obtained bounds for the variance of the waiting time of high- priority customers.

Walraevens et al. (2013) have presented study depth analytical of a semi – preemptive priority scheduling discipline. The discipline eliminates the deficits of both the full and non-preemptive versions under the non-preemptive category. They have used probability generating functions and the supplementary variable techniques. Guesmi & Djemal (2013) have presented a scalable architecture for a high performance IP switch based on Priority Active Queue Management (PAQM), which provides multimedia services with improved quality of service (QOS) in the communication system. A performance analysis of an optimized (PAQM) algorithm is presented using an NS-2 network simulator to evaluate the capacity of the internet protocol (IP) switch to support (QOS). The results show that this system can achieve the maximum through to put with low levels of delay. To achieve high performance, they have implemented the proposed algorithm using 0.35 μ m CMOS technology, the performance of which is subsequently analyzed. Sarhangian & Balcioglu (2013) have studied a first passage time problem for a class of spectrally positive levy processes. By considering the special case where the levy process is a compound Poisson process with negative drift .They obtained the Laplace–Stie1tjes transform of the steady state waiting time distribution of low priority customer in a two–class M/G/1 queue operating under a dynamic non- preemptive priority discipline.

Iftikhar et al. (2014) have focused to analyze a three queues priority model for low power Wireless Body Area Network (WBAN), which enables to provide guaranteed quality of service (QOS) parameters such as queue, queueing, through put and packet loss rate . They also simulate the behavior of traffic in (WBAN) to further evaluate the proposed analytical framework.

3. Methodology

One can specify many stochastic processes taking place in the described queueing systems. Some of the characteristics of these stochastic processes are of special interest and may well serve as system performance characteristics.

Let us begin with the notions of busy period and idle period (or vacation period). The busy period is the period of time during which the server is occupied either with servicing of the request or with the switching. The notion of busy period is intuitively absolutely clear. We shall call the periods of time which alternate busy periods by idle periods. It is clear that a busy period follows some idle periods and vice versa.

Let $\pi = \{ \pi^{(1)} , \pi^{(2)} , \ldots\ldots\}$ be consecutive busy periods of the system. One may consider that busy periods π are independent and identically distributed (i.i.d) random variables with some cumulative distribution function (c.d.f) π (t). The sequence π of consecutive busy periods in priority queueing system under all schemes but the "wait and see" mode of behavior of server is a sequence of (i.i.d) random variables. The busy periods in the system with "wait and see" mode of behavior of the server are independent due to Markovian property of the incoming flows [Bejan, (2007)].

3.1 Single Service M/ M/1 Model

Consider the (M/M/1) where M stands for Markoven, 1 server, the arrival and service rates are λ and μ, respectively. The service discipline is assumed to be first come first served (FCFS). Assuming that steady state, access rate is less than the rate of service (λ<μ). Moreover, if the waiting capacity is infinite, the queueing models assume that inter-arrival and service times are exponentially distributed, then the probability density function for the time between successive arrivals would be [Bastani (2009)]

$$\mathbf{f(t)} = \boldsymbol{\lambda e^{-\lambda t}} \qquad \mathbf{t \geq 0} \ , \boldsymbol{\lambda} > \mathbf{0} \qquad \textbf{(2-1)}$$

Equivalently, the arrivals can be said to follow the Poisson process, a collection $\{ N(t), t \geq 0 \}$ of random variable. Where N(t) is the number of customers that have occurred up to time (t) , starting from time 0 . The Poisson distribution is given by [Taha. A (2007)]

$$p_r\,\{N(t)\;\; t \geq 0 = \frac{(\lambda\mu)^n e^{-\lambda t}}{n!} \qquad (2\text{-}2)$$

We now proceed to compute some performance measures. The probability p is given by that the service provider is busy (the rate of use of the system)

$$\mathbf{P} = \frac{\lambda}{\mu} \qquad (2\text{-}3)$$

The possibility of disruption of facilities or service (the probability of the absence of any unit in the system)

$$\rho_0 = 1 - \frac{\lambda}{\mu} \qquad (2\text{-}4)$$

The probability of having one customer in the system

$$\rho_1 = (\frac{\lambda}{\mu})^n \;\; \rho_0 \qquad (2\text{-}5)$$

The probability of the existence of n customers in the system

$$\rho_n = (\frac{\lambda}{\mu})^n \;\; \rho_0 \qquad (2\text{-}6)$$

The average number of customers (service recipients) in the system

$$L_s = \frac{\lambda}{\lambda\mu} \qquad (2\text{-}7)$$

The average number of customers in the queue (the average length of the waiting row)

$$L_q = \frac{\lambda^2}{\mu(\mu-\lambda)} \qquad (2\text{-}8)$$

The average elapsed time for one customer in the system

$$W_s = \frac{1}{\mu-\lambda} \qquad (2\text{-}9)$$

The average elapsed time for one customer in the queue

$$W_q = \frac{1}{\mu(\mu-\lambda)} \qquad (2\text{-}10)$$

3.2 Priority Model

We consider a single server queueing system serving two types of customers; class-1 and class-2, each having its own respective line and the arrival process for both types is state independent. A higher priority is assigned to class-1. Suppose that the service rule within each class is FIFS and the priority system is preemptive resumed, i.e. during the service of low priority customer's service is interrupted and will be resumed again when there is no high priority customers in the system. We denote by the number of the customers of class i (i=1, 2) [Sarhangian (2011)].

Let the number of customers in the first class is restricted to a finite number L including the one being served, if any, and the number of the second class is infinite. Let also λ_1, λ_2 denote the arrival rates for the two classes and let μ_1,μ_2

denote the service rates for two classes respectively. Denote the traffic intensities by $\rho_{1=} {}^{\lambda_1}/_{\mu_1}$, $\rho_{2=} {}^{\lambda_2}/_{\mu_2}$ and the steady state probability that the system is in state (i , j), where i is the number of the high priority customers and j is the number of low priority customers in the system. Clearly, the governing difference equations of the system under consideration are given by [Tarabia (2007)].

$$(\lambda_1+\lambda_2)\rho_{0,0}=\mu_1\rho_{1,0}+\mu_2\rho_{0,1} \qquad (2\text{-}11)$$

$$(\lambda_1+\lambda_2+\mu_2)\rho_{0,j}=\lambda_2\rho_{0,j-1}+\mu_1\rho_{1,j}+\mu_2\rho_{0,j+1} \quad ,j\geq 1 \qquad (2\text{-}12)$$

$$(\lambda_1+\lambda_2+\mu_1)\rho_{i,0}=\lambda_1\rho_{i-1,0}+\mu_1\rho_{i,j-1} \quad 1\leq i\leq L-1 \qquad (2\text{-}13)$$

$$(\lambda_1+\lambda_2+\mu_1)\rho_{i,j}=\lambda_1\rho_{i-1}+\mu_1\rho_{i+1+j}+\lambda_2\rho_{i,j-1}, 1\leq i\leq L-1 \quad ,j\geq 1 \qquad (2\text{-}14)$$

$$(\lambda_2+\mu_1)\rho_{L-0}=\lambda_1\rho_{L-1,0} \qquad (2\text{-}15)$$

$$(\lambda_2+\mu_1)\rho_{L-1}=\lambda_1\rho_{L-1,j} \quad ,j\geq 1 \qquad (2\text{-}16)$$

4. Case study & the empirical results

The comparison between the obtained results concerning the performance measures in the case of without priority and with priority is performed at the National Bank of Egypt Zagazig Branch for the period time from 2 July to 4 August in 2014 as it is given in Table 1.

Table 1 (service Performance Rate without and with Priority from 2 July to 4 August 2014)

		all times				priority		
	average no. of tickets per hour				average no. of tickets per hour			
	arrival rate	service rate	Minutes	No. per hour	arrival rate	service rate	minutes	No. per hour
02-July	65.33	00:02:56	2.93333333	20.4545455	45	00:02:14	2.233333	26.86567
03-July	67.40	00:03:37	3.61666667	16.5898618	51.2	00:02:14	2.233333	26.86567
06--July	83.71	00:05:05	5.08333333	11.8032787	59.43	00:01:37	1.616667	37.1134
07-July	62.83	00:03:09	3.15	19.047619	44.67	00:01:55	1.916667	31.30435
08-July	60.40	00:04:02	4.03333333	14.8760331	43.2	00:02:47	2.783333	21.55689
09-July	64.60	00:03:24	3.4	17.6470588	47.6	00:02:19	2.316667	25.89928
10-July	71.40	00:03:05	3.08333333	19.4594595	55.4	00:02:27	2.45	24.4898
13-July	62.00	00:03:59	3.98333333	15.0627615	45	00:02:27	2.45	24.4898
14-July	60.20	00:03:51	3.85	15.5844156	41	00:02:25	2.416667	24.82759
15-July	40.33	00:03:29	3.48333333	17.2248804	29.17	00:02:21	2.35	25.53191
04 August	57.67	00:05:00	5	12	29	00:03:22	3.366667	17.82178

The analysis of these data yields the following results: in case of queue without priority we obtain: λ= 16.33, μ= 63.26, ρ= 0.25 , while in case of queue with priority we obtain λ= 42.39, μ= 107.26, ρ= 0.39, Let L= 20.

From the previous results, we can reach the following performance measures as it shows in Table 2.

Table 2 (Comparison between Queues without and with Priority)

Performance measure	Without priority	With priority
L_q	2	5
L_s	7	13
W_q	19.8	21.6
W_s	55.2	76.8

From this comparison, its clear that, the average number of customers in the queue (not counting the customer being served at the server's window) increases at a rate of 3 customer service expected performance borne and vice versa in the other way. It is the sum of the average number of customers in the queue plus sum of the average number of customers in the system more than doubled in the event of a priority.

The average wait time in the queue without priority = 19.8 minutes in case of a priority than the waiting time 2 minutes for each customer.

5. Conclusion

- The average number of customers in a queue = 2 and the average number of customers in the system = 7 which indicates that in case of priority, these is wasting time until the client gets the service.
- The average number of customers in a queue without priority = 5 and the number of customers in the system with priority = 13, this means that in the presence of a priority customer bears almost twice as much time to expect in the classroom to get service.
- The client takes around 19.8 minutes waiting to perform service while waiting 21.6 minutes in case of a priority.
- The customers with certain priorities either preemptive or non-preemptive affect negatively on the length of the queue falls to existing customers in the queue.

In order to avoid breakdown points in the performance of the bank. To save the time of the customer, it has to avoid the priority discipline:

1- Addition a property to ATM allows the customer to deposit either for each money or checks.

2- Canceling surcharges when withdrawals from ATMs in agreement with other banks and re-distributed geographically and increase the number of machines.
3- Transferring system must be applied on the account number directly.

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Solving the Problem of Tardiness Vessel Using a Simulated Model

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Abstract

A container terminal is a zone of the port where sea-freight dock on a berth and containers are loaded, unloaded and stored in a buffer area called yard. Nowadays congestion in ports becomes main focus for many researchers to analyze due to its huge importance in international trade and economic growth.

The objective of this paper is to apply simulation analytical methodologies for making the problem more detailed than theoretical algorithm. So, building a simulation model for vessel is to improve its performance especially in tardiness's Vessel by describing and classifying the main logistics processes and operations in container terminals for their optimization. Vessel Simulation model represent a real problem and possible changes that can be modified easily .with small adjustments in the model

Keywords: Vessel Arrivals, port congestion, world trade, Simulation, Container handling problems

1. Introduction

Transportation gateways(seaports, airports, and land border crossings) are the entry and exit points for international merchandise trade between Egypt and countries around the world, transportation gateways play critical roles in Egypt international merchandise trade and economy(Azevedo et al. (2009)).

Egyptian businesses depend on these seaports for facilitating the exchange of .merchandise with trading partners around the world Logistics, which reflects the management of the cargo flow and shipping service from origins to destinations, is one important channel in transportation. Seaports always play a strategic role in the development of domestic and international trade of a country whether it is a developing or developed country; ports play an active role in sustaining the economic growth of a country.

Countries with inefficient seaports have higher handling costs where transportation of goods in containers by sea has been the most important for round the world trade exchange and so port systems must have been nourished in the recent decades (Liao, (2017)) Supporting and financing port development projects nowadays returns with huge impact in economic growth and for some countries, it become their main national income.

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Challenge coping with rapid changes in modern world that have huge intensive changes occurring like some congestions in hub ports and even smaller ports which sometimes blocks the waterway causing huge delays in transit time impacting service time upon vessel arrivals to ports pressing port facilities and shorter time maintenance to strive with the flow without delaying services causing facilities to crash being restless efforts serving vessels.

Congestions drastically increase the costs of freight, consumers /traders, .travel time and reduce freight flow, reliability and predictability (Guan, (2016)) introduces the delay at the port facilities as one of the pressing issues facing the industry. It performs critical functions of pickup and delivery of containers to and from the terminal for shippers which threated the productivity and compromises service level.

The objective of this paper is to build a simulation model for vessel is to improve its performance especially in tardiness's Vessel by describing and classifying the main logistics processes and operations in container terminals for their optimization. Vessel Simulation model represent a real problem and possible changes that can be modified easily with small adjustments in the model.

This paper is organized as follows. Section2 introduces "literature review" about the problem. Section 3 considers **"Problem definition**". Section 4 presents "**The methodology of simulation model**". Section 5 introduces "**The proposed model for solving the real problem"**. Section 6 presents **"the results and recommendations"** and finally Section 7 **"Conclusion"**.

2. Literature review

This section shows the literatures review about the recent published researches. The port industry is under pressure to deal with the ever increasing freight volume.

Port congestion at marine container terminal is considered a major issue facing vessels to berth. Countries with inefficient seaports have higher handling costs where transportation of goods in containers by sea has the most important for round the world trade exchange.

Table1 **Literature review**

Author	Application	Method
Pham (2007)	US Marine Terminals	He Implements and compared four regression techniques to utilize webcam data to predict truck queuing time.
Azevedo et all (2009)	Container Terminals in the Iberian Seaports	They quantified the performance using DEA 'Data Envelopment Analysis' & Data Mining together comparing Operational Data of ports.
Fan (2010)	Europe & Northern America	He developed an optimization model under conditions of congestion and stochastic variables that optimizes network flow.
Wang (2013)	US Port Trailer crossdock	Decreased transportation lead time using dynamic simulation models to compare FCFS, Look-ahead, Min. processing time methods.
Baran & Gorecka (2015)	Singapore, Hongkong, Rotterdam & Hamburg	They used DEA & MPI 'Malmquist Productivity Index' to compare technical efficiency in productivity of container port than technological.
Guan (2016)	California- US	Applied multi server queuing model to analyze terminal gate congestion and quantify truck costing time.
Liao (2017)	Santos- Brazil	Compared theoretical model 'stochastic queuing model' and analytical tool ' simulation model' to shorten loading/unloading truck at docks

3. Problem definition

Port operations are difficult to derive analytically. For this reason, simulation models have been developed in maritime transportation. Most of them do not represent the whole infrastructure and/or operations and they can be classified in groups as port/terminal operations and logistics, vessel traffic. Simulation is a process of analysis and synthesis, useful as a tool to aid decision making in complex productive processes. By closer attention of inputs of modeling vessel arrivals in ports and observing the resulting outputs, were valuable insight may be obtained into which variables are most important and how variables interact to reinforce analytic solution methodologies. Therefore, it is understood as simulation of all the process of elaboration of a computational model representative of a real (or hypothetical) system and the conduction of experiments in order to understand the behavior of a system.

Traffic rules can allow changes to them. A control and traffic verification agent has been shown to be relevant and should be considered. The more detailed these rules are, the more accurate the results will be. It might also help to identify hidden traffic management problems behind simulation results and new traffic management strategies could be implemented.

4. Methodology of Simulation Model:

Simulation model is the decision making tool which imitates the operation of a real-world process or system over time, Simulation enables the study of and experimentation with the internal Interactions of a complex system, or of a subsystem within a complex System. Informational, organizational and environmental changes can be simulated and the effect of those alternations on the model's behavior can be observer. The knowledge gained in designing a simulation model can be of great value toward suggesting improvement in the system under investigation.

5. The proposed Model

The System is affected by changes occurring outside the system such as some factors would affect arrival of vessels this relationship considered an activity of a system as in Table 2 which presents the system activities

Table 2 The System Activities

System	Entities	Attributes	Activates	Events	State/Variables
Sea Ports	Vessels	Marking arrival times	Berthing, Runways	Arrivals, Departures, Vessel service time	Number of docks Number of / waiting vessels

Schedule of vessels to port for berthing one by one to be served with least service time so once vessel arrives till its departures as following Table 3 shows time between arrivals

Table 3 The Time between Arrivals Distribution

Time between arrivals (Days)	Frequency	Probability	Cumulative probability	Radom Digit Assignment
0	879	0.58	0.58	00-57
1	469	0.31	0.90	58-89
2	155	0.10	1.00	90-99
Total	1503	1.00	-	-

This randomness is simulated in Excel by generating random numbers in compliance with a determined probability distribution (Poisson, Exponential, normal, Weibull, etc.). The amount of vessel calls sea ports generated in the model, for the period, should converge to the value defined by the arrival rate. The average time vessel takes berthing showed as below in Table 4.

Table 4 Service time Distribution

Service Time (Days)	Frequency	Probability	Cumulative Probability	Random Digit Assignment
Small / 1.5	141	0.11	0.11	00-10
Medium/ 2	336	0.25	0.36	11-35
Large / 3	861	0.64	1.00	36-99
Total	1338	1.00	-	-

Table 4 is designed specifically for a double-channel queue dock with 3rd general dock which is used in case of emergency that both main container docks are busy which serves vessels on a first-in, first-out (FIFO) basis. It keeps track of the clock time at which each event occurs. The second column of Table 2 records the clock time of each arrival event, while the last column records the clock time of each departure event Sokhna port.

Simulation is used when it is not possible to experiment with the real system (for example, to the time required to perform the experiment, or to the high cost of the experiment, or to the difficulty of physically carrying the experiment (Liao, 2017). This is also the great advantage of simulation, allowing real studies of systems without modifying them, with speed and low cost when compared to the real physical and organizational changes necessary to study the same alternatives of future scenarios.

Finally, another extremely important parameter is how many replications / rounds or samples of the simulation will be made. As in simulation random variables are provided using probability distributions, running the simulation for just one day does not mean that on that day we will have a "typical" day

Another important factor for analysis of the solution is the average occupation rate of the docks, the curves of the mean time and total time in the system as a function of the average occupancy rate provide a curve that closely resembles the theoretical model; the curve has an exponential behavior at the beginning tending to linearity as the number of door increases. It does not make any difference to have more doors to receive loads, because their occupancy rate reaches almost 50% of the total capacity.

Table 5 shows the average of total time of use the docks after closing of the time window of 8 hours for vehicle reception which represents vessel simulation arrivals.

Table 5 The Results of Simulated Vessel Arrival Mode

Simulation Table for Vessel's Arrival

Vessels	RN1	Time between arrivals	Arrivals	RhE	Vessel Capacity	Service Time	Service Beginning	Server Doc kfLane	Waiting Time	Service Ending	Total Time
1	52	0	0	39	L	3	0	1	0	3	3
2	38	0	0	23	M	2	0	2	0	2	2
3	53	0	0	82	L	3	0	3	0	3	3
4	66	1	1	36	L	3	1	2	1	4	4
5	98	2	3	10	S	1.5	3	1	0	4.5	1.5
6	47	0	3	66	L	3	3	3	0	6	3
7	90	2	5	50	L	3	5	2	0	8	3
8	43	0	5	51	L	3	5	1	0	8	3
9	34	1	6	95	L	3	6	3	0	9	3
10	98	2	3	85	L	3	8	2	0	11	3
11	24	0	3	23	M	2	8	1	0	10	2
12	34	0	3	22	M	2	8	3	1	11	3
13	81	1	9	21	M	2	9	1	1	12	3
14	53	0	9	93	L	3	9	2	2	14	5
15	91	2	11	22	M	2	11	3	0	12	2
16	51	0	11	34	L	3	11	1	1	15	4
17	37	1	12	10	S	1.5	12	3	0	13.5	1.5
18	TO	1	13	34	L	3	13	3	05	16.5	3.5
19	as	1	14	36	L	3	14	3	0	17	3
20	94	2	16	25	M	2	16	2	0	18	2
21	98	2	18	14	M	2	18	1	0	20	2
22	59	1	19	51	L	3	19	3	0	22	3
23	56	0	19	43	L	3	19	2	0	22	3
24	92	2	21	34	M	2	21	1	0	23	2
25	33	0	21	9	S	1.5	21	2	1	23.5	2.5
26	24	0	21	22	M	2	21	3	1	24	3
27	60	1	22	19	M	2	22	1	1	25	3
23	46	0	22	55	L	3	22	2	15	26.5	4.5
29	64	1	23	91	L	3	23	3	1	27	4
30	26	0	23	36	L	3	23	1	2	28	5
31	36	1	24	6	S	1.5	24	2	25	28	4
32	30	0	24	72	L	3	24	3	3	30	6
33	93	2	26	53	L	3	26	1	2	31	5
34	22	0	26	18	M	2	26	2	2	30	4
35	99	2	23	44	L	3	23	2	2	33	5
36	60	1	29	65	L	3	29	3	1	33	4
37	1	0	29	91	L	3	29	1	2	34	5
38	93	2	31	23	M	2	31	2	2	35	4
38	17	0	31	36	L	3	31	3	2	36	5
40	60	1	32	45	L	3	3	1	2	37	5
Sum			32				102	602		765.5	136.5
Average			0.8				2.55	15.05		19.1375	3.4125

6. Recommendations Analysis and results

Since the simulation is based on the time that mainly measures the average total time starting from arrival till departure. After closer observation of the outcome and its comparison to objective, some aspects hereby found as follows:

- The average of inter arrival time of each Vessel is almost one day as per 40 runs 0.8 ~1.
- The average of waiting time almost one day/40 runs 0.8625 ~1.
- The average of total time of each Vessel is almost 3 days and 12 hours as per 40 runs
- The average of service time of each Vessel is almost 2 day and 12 hours per 40 runs. The average of service ending time of each Vessel is almost 19 day as per 40 runs 0.8 ~1.

7. Conclusion

In this paper, the vessel simulation model is built on real life data. We recognize the main features of system that affecting on tardiness. The performance can be improved and optimized through applying the recommendations to the operations in container terminals.

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Design an Optimal System with Fuzzy Multiple Objective De Novo Programming approach

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Abstract:

The De Novo Programming Problem (DNPP) is an extended concept to traditional Multiple Objective Programming (MOP) problem. DNPP was suggested by **Milan Zeleny** (1980). It is robust tools to design a new optimal system that can be minimize or even eliminate the tradeoffs between objectives of the original problem. In real cases, the nature of parameters is ambiguous and not precisely known. In this paper a Fuzzy Multiple objective De Novo Linear Programming (FMODNLP) model is developed to reformulate the MOPP with fuzzy parameters.

Keywords: Fuzzy Multi-objective De Novo Linear programming; Multi-objective programming; De Novo Programming Problem; Optimal System Design; Linear membership function; meta-optimum system; optimal path ratio.

1. Introduction:

In the beginning of 1980's, **Milan Zeleny** introduced de novo programming approach as a robust tool to optimize the MOPP using a new optimal system design in which the available resources in the original problem MOPP converted form constant to be decision variables with the basic decision variable.

The Multiple Objective De Novo Programming Problems (MODNPP) enables us to either minimize or eliminate the conflicting between the objectives function that impossible to satisfy all of them in the same multiple objective programming model. The FMODNLP reformulate the MOPP given the prices of resources and budget respectively. In the realistic situations the parameters of the objectives and constraints are a vague and not precisely known. Due to this the (FMODNLP) model is introduced. After reformulation of (FMODNLP) the Meta Optimum System (MOS) is introduced for searching for a best performance of a given budget. The Optimum Path Ratio (OPR) concept is applied to provide an efficient optimal system. The researches that applied the de novo programming are very rare. **Milan Zeleny (1980)** applied the de novo programming for single objective, **Milan Zeleny (1981**) extended the de novo programming for multiple objectives, **Bare and Mendoza (1988)** applied de novo programming to single and multi-objective forestry land management problems. **Bare and Mendoza (1990)** provides yet another application in the field of forest land management.

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Li and Lee (1990) extended the de novo programming methodology with fuzzy decision theory. A mathematical example was shown which considered all de novo model parameters as fuzzy, **Chen (2006)** considered DNPP as a fuzzy multi stage, **Fiala, Petr (2011)** Applied linear programming approach to solve MODNPP, **Umarusman, N. (2013)** used the min max goal programming to solve the MODNLPP, **and Zhuang, Z. Y., & Hocine, A. (2018)** solved the MODNPP by meta goal programming approach.

This paper is organized as follows: the FMODNLP in section 2, illustrative example is presented in section 3, and finally, section 4 discusses the conclusion.

2. The Fuzzy Multiple Objective De Novo Linear Programming:

In this section, the process of decision making through reformulate an optimal system that better than MOP problem model and then construct MOS are reviewed:

Consider the standard model of MOLP

$$\left.\begin{aligned} &\max z_k = \sum_{j=1}^{n} C_{kj} X_j, && \text{k} = 1,2,\ldots,l, \\ &\text{subject to:} \\ &\sum_{j=1}^{n} a_{ij} X_{j_i} \le b_i, && i = 1,2,\ldots,m, \\ &X_j \ge 0, && j = 1,2,\ldots,n \end{aligned}\right\} \quad (1)$$

Where the parameters b_i represent the given available resources as constant. The efficient solution concept resulting from the solution of MOLP model. To obtain the DNPP formulation we have to change b_i from constants to variables with their values to be determined as follows:

$$\left.\begin{aligned} &\max z_k = \sum_{j=1}^{n} C_{kj} X_j, && \text{k} = 1,2,\ldots,l, \\ &\text{subject to:} \\ &\sum_{j=1}^{n} a_{ij} X_{j_i} - b_i \le 0, && i = 1,2,\ldots,m, \\ &\sum_{j=1}^{m} p_i b_i \le B, \\ &X_j \ge 0, && j = 1,2,\ldots,n \end{aligned}\right\} \quad (2)$$

Where $X_j . b_i$ are decision variables for products and available resources respectively, p_i, B are the given of both the unit price of resource i and total available budget respectively.

2.1 FMODNLP:

The parameters of the optimization model are usually vague and uncertain. Zimmermann (1978) used Bellman and Zadeh (1970) to reformulate Linear Programming Problem (LPP) with fuzzy goals and constraints respectively thus can be solved as a conventional LPP.

A FMODNLP problem can be reformulated as a conventional LPP as:

$$
\left.\begin{aligned}
&\max \tilde{z}_k = \sum_{j=1}^{n} \tilde{C}_{kj} X_j, && K = 1,2,\ldots,l,\\
&\text{subject to:}\\
&\sum_{j=1}^{n} a_{ij} X_j - b_i \le 0, && i = 1,2,\ldots,m,\\
&\sum_{j=1}^{m} \tilde{p}_i b_i \le \tilde{B},\\
&X_j \ge 0, && j = 1,2,\ldots,n
\end{aligned}\right\} \quad (3.a)
$$

Where $\tilde{C}_{kj}, \tilde{p}_i, \tilde{B}$ are fuzzy values.

The preceding model can be reformulated by defining unit cost $v_j = p_i b_i$ as follows:

$$
\left.\begin{aligned}
&\max \tilde{z}_k = \sum_{j=1}^{n} \tilde{C}_{kj} X_j, && K = 1,2,\ldots,l,\\
&\text{subject to:}\\
&\sum_{j=1}^{n} \tilde{v}_i \tilde{x}_i \le \tilde{B}, && i = 1,2,\ldots,m,\\
&X_j \ge 0, && j = 1,2,\ldots,n
\end{aligned}\right\} \quad (3.b)
$$

According to Zimmermann (1978), the optimization system is formulated by solving each objective individually to obtain $z_k^L = \min z_k$, s.t. $x_i \in X =$ and $z_k^u = \max z_k$, s.t. $x_i \in X$

The linear membership function for fuzzy objectives is considered as follows:
$\forall\ \mathrm{k} = 1,2,\ldots,l$:

$$
\mu_{z_k}(x) = \begin{cases} 0 & z_k \le z_k^L \\ \dfrac{z_k - z_k^L}{z_k^U - z_k^L} & z_l \le z_k \le z_u \\ 1 & z_k \succ z_k^U \end{cases} \quad (4)
$$

The linear membership functions for fuzzy maximization and minimization constraints are considered as follows:

$$
\mu_{g_i(x)} = \begin{cases} 0 & \forall g_i(x) \ge b_i + d_i \\ 1 - \frac{g_i(x) - b_i}{d_i} & \forall\ b_i \le g_i(x) \le b_i + d_i \\ 1 & \forall g_i(x) \le b_i \end{cases} \quad (5)
$$

After constructing the membership function defined in (4) and (5), the compromise solution is obtained from intersection between both fuzzy objectives and constraints respectively.so that to obtain compromise solution Zimmerman (1978) suggested the following model that equivalent to fuzzy model as:

$$\left.\begin{array}{ll} \max \lambda & \\ \text{subject to:} & \\ \lambda \le (\sum_{k=1}^{l} C_{kj} X_j - z_k^L)/(z_k^U - z_k^L), & k = 1,2,...,l, \\ \lambda \le (\sum_{i=1}^{m} g_i(x) - b_i)/d_i & \\ \sum_{j=1}^{n} A_j X_j \le B & j = 1,2,....,n \\ \lambda \in [0,1], X_j \ge 0. & \end{array}\right\} \quad (6)$$

The solution resulting from the last model contributes in formulating the MOS as:

$$\left.\begin{array}{ll} \min z = \sum_{j=1}^{n} v x_i, & \\ \text{subject to:} & \\ C_{kj} X_j \ge z_k^*, & K = 1,2,...,l \\ X_j \ge 0, & j = 1,2,...,n \end{array}\right\} \quad (7)$$

According to Fiala, P. (2011) the solution of MOS model provides solution as:

$$x^*, B^* = vx^*, b^* = a_{ij} x^*. \quad (8)$$

A minimal budget to accomplish z^* through x^* and b^* is identified by B^* value.

The OPR to accomplish the best performance for a given budget is considered as:

$$r = \frac{B}{B^*}. \quad (9)$$

Fiala, P. (2011) mention that the OPR is fast and robust tool for redesigning an efficient optimal large- scale systems. The OPR for B

$$x = rx^*, b = rb^*, z = rz^*. \quad (10)$$

2.2 The computational of Solution procedure to the proposed approach:

Step 1: Formulate the FMODNLP problem**.**

Step 2: Solving each objective function individually subject to given constraints of system.

Step 3: Use step2 to determine the lower and upper bound respectively for each objective.

Step 4: Based on step 3, construct the membership function for goals and constraints respectively.

Step 5: Formulate the problem (6).

Step 6: From step 5, the resulting solution is used to formulate the MOS and hence the OPR.

3. Illustrative example:

To test the FMODNLP, the same example of Zeleny, M. (1986) has been used with fuzzy parameters.

$$\begin{aligned}
&\text{Max}\, Z\ = \tilde{5}0x_1 + 1\tilde{0}0x_2 + 1\tilde{7}.5x_3 \\
&\text{Max}\, Z_2 = \tilde{9}2x_1 + \tilde{7}5x_2 + \tilde{5}0x_3 \\
&\text{Max}\, Z_3 = \tilde{2}5x_1 + 1\tilde{0}0x_2 + \tilde{7}5x_3 \\
&\qquad \text{s.t.} \\
&\qquad 12x_1 + 17x_2 \le b_1, \\
&\qquad 3x_1 + 9x_2 + 8x_3 \le b_2, \\
&\qquad 10x_1 + 13x_2 + 15x_3 \le b_3, \\
&\qquad 6x_1 + 16x_3 \le b_4, \\
&\qquad 12x_2 + 7x_3 \le b_5, \\
&\qquad 9.5x_1 + 9.5x_2 + 4x_3 \le b_6, \\
&\qquad 0.\tilde{7}5\, b_1 + 0.\tilde{6}0\, b_2 + 0.\tilde{3}5\, b_3 + 0.\tilde{5}0\, b_4 + 1.\tilde{1}5\, b_5 + 0.\tilde{6}5\, b_6 = 46\tilde{5}8.75, \\
&\qquad x_1, x_2 \ and \ x_3 \ge 0.
\end{aligned}$$

According to (3.b) the model can be rewrite as:

$$\begin{aligned}
&\text{Max}\, Z\ = \tilde{5}0x_1 + 1\tilde{0}0x_2 + 1\tilde{7}.5x_3 \\
&\text{Max}\, Z_2 = \tilde{9}2x_1 + \tilde{7}5x_2 + \tilde{5}0x_3 \\
&\text{Max}\, Z_3 = \tilde{2}5x_1 + 1\tilde{0}0x_2 + \tilde{7}5x_3 \\
&\qquad \text{s.t.} \\
&23.475x_1 + 42.675x_2 + 28.7x_3 = 4658.75 \\
&\qquad x_1, x_2 \ and \ x_3 \ge 0.
\end{aligned}$$

Steps 2 and 3: Finding the upper and lower bound by solving each objective as a single and construct the payoff table:

	Z_1	Z_2	Z_3	X_1	X_2	X_3
Max Z_1	10916.81	8187.61	10916.81	0	109.1681	0
Max Z_2	9922.79	18257.93	4961.395	198.4558	0	0
Max Z_3	2840.702	8116.29	12174.43	0	0	162.3258

$$\begin{aligned}
&2840.702 < z_1 < 10916.81, \\
&8116.29 < z_2 < 18257.93, \\
&and \quad 12174.43 < z_3 < 4961.395.
\end{aligned}$$

Step 4: Construct the membership function for all fuzzy goals and fuzzy constraints:

$$\mu_{Z_1}(x) = \frac{(50x_1 + 100x_2 + 17.5x_3) - 2840.702}{10916.81 - 2840.702}$$

$$\mu_{Z_2}(x) = \frac{(92x_1 + 75x_2 + 50x_3) - 8116.29}{18257.9 - 8116.29}$$

$$\mu_{Z_2}(x) = \frac{(25x_1 + 100x_2 + 75x_3) - 4961.395}{12174.43 - 4961.395}$$

$$\mu g_i(x) = \frac{(23.475x_1 + 42.675x_2 + 28.7x_3) - 4000}{4658.75 - 4000}$$

$$\mu g_i(x) = \frac{7000 - (23.475x_1 + 42.675x_2 + 28.7x_3)}{7000 - 4658.75}$$

Step 5: Formulate the equivalent crisp formulation of the fuzzy optimization problem as:

$$\max \quad \lambda$$

subject to

$$\frac{(50x_1 + 100x_2 + 17.5x_3) - 2840.702}{10916.81 - 2840.702} \geq \lambda,$$

$$\frac{(92x_1 + 75x_2 + 50x_3) - 8116.29}{18257.9 - 8116.29} \geq \lambda,$$

$$\frac{(25x_1 + 100x_2 + 75x_3) - 4961.395}{12174.43 - 4961.395} \geq \lambda,$$

$$\frac{(23.475x_1 + 42.675x_2 + 28.7x_3) - 4000}{4658.75 - 4000} \geq \lambda,$$

$$\frac{7000 - (23.475x_1 + 42.675x_2 + 28.7x_3)}{7000 - 4658.75} \geq \lambda$$

$$x_1, x_2, and\ x_3 \geq 0, \qquad b_1, b_2, b_3, b_4, b_5, and\ b_6 \geq 0, \qquad \lambda = [0,1],$$

Step 6: Lingo software program has been used to solve the preceding crisp model, the solution obtained as: $\lambda = 0.69$, $x_1^* = 110.63, x_2^* = 15.35$ and $x_3^* = 74.7$,

$b_1^* = 1588.52, b_2^* = 1067.631, b_3^* = 72426.362, b_4^* = 1859.006, b_5^* = 707.0706, and\ b_6^* = 1495.628$.

From this result the optimal system performance is

$z_1^* = 8373.72,\ z_2^* = 15064.42$ and $z_3^* = 9903.11$.

Use the values of z_k^* in order to formulate the MOS as:

$$\text{Max } Z = 23.475x_1 + 42.675x_2 + 28.7x_3$$
$$s.t$$
$$50x_1 + 100x_2 + 17.5x_3 \geq 8387.719$$
$$92x_1 + 75x_2 + 50x_3 \geq 15064.422$$
$$25x_1 + 100x_2 + 75x_3 \geq 9903.113$$
$$x_i \geq 0,$$

The solution of the MOS is:

$$B^* = vx^* = 5395.987$$

From (9) the OPR = $\frac{4658.75}{5395.987} = 0.86$

From (10) the optimal system of given budget B is designed as:

$$x_1 = 95.52, x_2 = 13.25, \text{ and } x_3 = 64.5,$$
$$b_1 = 1371.5, b_2 = 921.77, b_3 = 2094.86, b_4 = 1605, b_5 = 610.5, \text{ and } b_6 = 1291.28,$$
$$z_1 = 7229.64, z_2 = 13006.22, \text{ and } z_3 = 8550$$

The preceding results of the proposed FMODNLP approach show that the level of objectives satisfactions is increased from Li, R. J., & Lee, E. S. (1990) $\lambda = 0.56$ to $\lambda = 0.69$.

The proposed approach applied the MOS and OPR concepts to design a new and efficient optimal system.

4. Conclusion:

In this paper, the de novo programming is considered with fuzzy parameters, the advantages of this approach is to enable the decision makers (DMs) to deal with the lake of information and imprecision data in the parameters. The proposed approach is more flexible and applicable for the de novo programming problem with fuzzy parameters. The FMODNLP applied the linear membership function to obtain a set of efficient solution allowed to the DMs. The concepts of MOS and OPR applied to develop a new and efficient large-scale linear model.

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Solving Production Problem with Fuzzy Multi-Objective Using Goal Programming

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Abstract

In industrial field, the multi-objective optimization problem includes variety of challenges. It is observed that there is a lack of precise information in various parameters that need utmost attention. In the real world, production planning model contains a fuzzy coefficients which could be solved using modified S-curve.

In this paper, the modified Chocoman model is presented. The new model of multi-objectives contains fuzzy coefficients in two objectives (revenue and profit). First, the fuzzy multi-objectives model is transformed to crisp using the modified S-curve membership function. Then, the goal programming is introduced by adding deviational variables to be new goals to minimize deviations in goals. By the end of this paper, we succeed reaching to best compromise of decision variables in goals.

Keywords: modified Chocoman model, fuzzy multi-objectives model, modified S-curve membership function, goal programming

1. Introduction

The modern trend in industrial application problem deserves modeling of all relevant or fuzzy information involved in a real decision making problem. S-curve membership function, referred as the non-linear membership function has been used in problems involving fuzzy coefficients. For the problem in this paper, a modified S-curve membership function (P. vasant, 2005) is applied to solve the first part of the problem which assimilates in the fuzzy coefficients in the objective functions. Either regarding the second part of the problem assimilates in solving multi-objective industrial production planning problem by using goal programming with deviational variables. Prior research works in the field of fuzzy linear programming with fuzzy objective function coefficients are enormous.

Literature contains several works from (pandian, M.V., et al., 2002), (pandian vasant, et al., 2005), (pandian, M. 2006), (sani susanto, et al., 2006), (pandian, M. vasant, et al., 2006), (sani susanto, et al., 2006) and many others.

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In this paper, the fuzzy linear programming with fuzzy objective function coefficients is solved using modified S-curve membership function. Then, the goal programming with deviational variables is applied. We modified the model of chocoman company USA. The data for this problem has been adopted from the data-bank of chocolate Inc., USA (sani susanto, et al., 2006), (alaa sheta, et al., 2012).

In part two, the goal programming is applied on modified chocoman problem; adding deviational variables to objective functions hoping to minimize deviations in goals. As an analyst, we seek the best methodologies for the decision makers with fuzzy objective coefficient and maximizing five objective functions in order to identify a final decision to satisfy a decision maker's goals.

The main objective of this paper is to solve the modified well-known chocolate industrial problem using fuzzy linear programming and goal programming algorithms.

This paper is organized as follows: Section 2 presents "Fuzzy linear programming" which particular case of the logistic function and Membership function in coefficient of the objective function and this section includes sub-sections 2.1 "Modified S-Curve Membership Function" & Section 2.2 "The membership function of fuzzy coefficients in objective function $\tilde{C}(j)$". Section 3 considers "goal programming". Section 4 presents "Problem definition". Section 5, shows "Solving the modified Chocoman problem" and finally Section 6 presents "Conclusion".

2. Fuzzy Linear Programming

The methodology of fuzzy linear programming has references to various works by (zimmermann, HJ, 1976), (verdegay, JL, 1982), (chanas, S, 1983), (carlsson, C and korhonen, P, 1986) and (werners, B., 1987). The fuzzy linear programming FLP is based on the interactive with decision maker in order to find a compromised satisfactory solution for the FLP problem. In fuzzy model, the objective function coefficients may be fuzzy, instead of being precise numbers as in a crisp model. For example, revenue, profit, cost and so on in a production planning center are always imprecise because of incomplete information and uncertainty in various potential suppliers and environments. Therefore, the fuzzy objective coefficients are considered in this paper.

2.1 Modified S-Curve Membership Function

The modified S-curve membership function is a particular case of the logistic function with specific values of B, C and α. These values are to be found.

$$\mu(x) = \begin{cases} 1 & x < x^a \\ 0.999 & x = x^a \\ \frac{B}{1+Ce^{\alpha x}} & x^a < x < x^b \\ 0.001 & x = x^b \\ 0 & x > x^b \end{cases} \quad (1)$$

where μ is the degree of membership function

As shown in function (1), the S-curve, is the membership function and it is defined as 0.001≤ μ(x)≤0.999. This range is selected because in manufacturing systems the work force need not always be 100% of the requirement. At the same time, the work force will not be 0%. Therefore, there is a range between x^a and x^b with 0.001≤ μ(x)≤0.999.This concept of range of μ(x) is used in an illustrative example (pandian, MV, 2002) and (pandian, MV, et al., 2002).

We rescale the x-axis as x^a =0 and x^b =1 in order to find the values of B, C and α. (Nowakowska, N, 1977) has performed such a rescaling in his work in social sciences. The values for C = 0:001001001, B=1 and a=13.81350956.

This logistic function is given by the following equation (3) (Goguen, JA, 1969), (Zadeh, LA, 1971), (Zadeh, LA, 1975) & (vasant, p., 2003) as follows:

2.2 The Membership Function Of Fuzzy Coefficients In Objective Function $\tilde{C}(j)$

The membership function of $\tilde{C}(j)$ is defined as follows:

$$\mu(c_j) = \begin{cases} 1 & c_j < {c_j}^a \\ 0.999 & c_j = {c_j}^a \\ \frac{B}{1+Ce^{\alpha(c_j - {c_j}^a / {c_j}^b - {c_j}^a)}} & {c_j}^a < c_j < {c_j}^b \\ 0.001 & c_j = {c_j}^b \\ 0.000 & c_j > {c_j}^b \end{cases} \quad (2)$$

Where $\mu(c_j)$ is the membership function of c_j and ${c_j}^a$ and ${c_j}^b$ are the lower and the upper boundary of the fuzzy coefficient of $\tilde{C}(j)$, respectively. The number $\mu(c_j)$ = 1 and $\mu(c_j)$ = 0 corresponds to the ‘crisp’ values. ${c_j}^a < \tilde{C}(j) < {c_j}^b$ is the fuzzy region.

The membership function of fuzzy coefficient in objective function $\tilde{C}(j)$ is given as:

$$\mu_{c_j} = \frac{B}{1+Ce^{\alpha(c_j - {c_j}^a / {c_j}^b - {c_j}^a)}} \quad (3)$$

By rearranging exponential term & taking $\log_e$ both sides Hence reaching to

$$c_j = c_j{}^a + \left(\frac{c_j{}^b - c_j{}^a}{\alpha}\right) \ln \frac{1}{C} \left(\frac{B}{\mu_{c_j}} - 1\right) \qquad (4)$$

Since c_j is a fuzzy coefficient in the objective function as in Equation (5), it is denoted as $\tilde{C}(j)$.

$$\tilde{C}(j) = c_j{}^a + \left(\frac{c_j{}^b - c_j{}^a}{\alpha}\right) \ln \frac{1}{C} \left(\frac{B}{\mu_{c_j}} - 1\right) \qquad (5)$$

The membership function for μ_{c_j} and the fuzzy interval, $c_j{}^a$ to $c_j{}^b$, for $\tilde{C}(j)$

3. Goal Programming

Goal Programming (GP) is a multi-criteria decision making technique (charnes, 1955) and (charnes and cooper, 1961). It is traditionally seen as an extension of linear programming to include multiple objectives, expressed by means of the attempted achievement of goal target values for each objective.

Another way of viewing the relationship is that linear programming can be considered to be a special case of goal programming with a single objective. All of these considerations place goal programming within the paradigm of multiple objective programming.

GP is now an important area of multi-criteria optimization. The idea of goal programming is to establish a achieve level of achievement for each criterion. GP is ideal for criteria with respect to which target (threshold) values of achievement are of significance. Goal programming is distinguished from linear programming by:

- The conceptualization of objectives as goals.
- The assignment of priorities and/or weights to the achievement of the goals.
- The presence of deviational variables d_i^+ *and* d_i^- to measure overachievement and underachievement from target (threshold) levels t_i.
- The minimization of weights sum of deviational variables to find solution that best satisfy the goals.

4. Problem Definition

The firm chocoman, Inc. (sani susanto, et al., 2006) manufactures 8 different kinds of chocolate products. There are 8 raw materials to be mixed in different proportions and 9 processes (facilities) to be utilized having limitations resources of raw materials. The problem can be presented as multi-objective functions (alaa sheta, et al., 2012) with two of those functions have fuzzy objectives in coefficients and 8 parameters to be optimized and 29 non-fuzzy constraints that should be satisfied by the end of the solution processes.

The decision variables for the chocolate problem are defined as:
X_1 = milk chocolate of 250g to be produced
X_2 = milk chocolate of 100g to be produced
X_3 = crunchy chocolate of 250g to be produced
X_4 = crunchy chocolate of 100g to be produced
X_5 = chocolate with nuts of 250g to be produced
X_6 = chocolate with nuts of 100g to be produced
X_7 = chocolate candy to be produced
X_8 = chocolate wafer to be produced

Here, we consider the problem of chocolate production planning in which the two of objectives function coefficients are fuzzy. The fuzzy linear multi-objective programming model for this problem is as follows:

$$F_1: maximize\ z_1 = \sum_{j=1}^{8} \tilde{C}(j) X_j$$
$$F_2: maximize\ z_2 = \sum_{j=1}^{8} \tilde{C}(j) X_j$$
$$F_3: maximize\ z_3 = \sum_{j=1}^{6} C(j) X_j$$
$$F_4: maximize\ z_4 = \sum_{j=1}^{8} C(j) X_j$$
$$F_5: maximize\ z_5 = \sum_{j=1}^{8} C(j) X_j$$

(6)

$$s.t \quad \sum_{i=1}^{29} \sum_{j=1}^{8} a_{ij} X_j \le b_i$$

where a_{ij} and b_i are non-fuzzy parameters, and $\tilde{C}(j)$ of F_1 & F_2 are fuzzy parameters, $c(j)$ of F_3, F_4 & F_5 are non-fuzzy parameters, $c(j), X_j \ge 0, j = 1,2,\dots,8$.

The following objective functions and constraints are established by the production planning department of chocoman Inc. We add new objective with fuzzy values thus, the modified Chocoman problem is shown as follows:

(Maximization – five objective functions)

F_1: Revenue

$[281,469]x_1+[112,188]x_2+[301,499]x_3+[120,200]x_4+[313,523]x_5+[130,218]x_6+[300,502]x_7+[112,188]x_8$

F_2: profit

$$[135,225]x_1+[62,104]x_2+[115,191]x_3+[54,90]x_4+[97,162]x_5+[52,87]x_6+[156,261]x_7+[62,104]x_8$$

F_3: market share for chocolate bars

$$0.25x_1+0.1x_2+0.25x_3+0.1x_4+0.25x_5+0.1x_6$$

F_4: units produced

$$F_4= x_1+x_2+x_3+x_4+x_5+x_6+x_7+x_8$$

F_5: plant utilization

$$1.65x_1+0.9x_2+1.975x_3+1.03x_4+1.75x_5+0.94x_6+4.2x_7+1.006x_8$$

Subject to

$$X_1-0.6x_2 \leq 0$$

$$X_3-0.6x_4 \leq 0$$

$$X_5-0.6x_6 \leq 0$$

$$-56.25x_1-22.5x_2-60x_3-24x_4-63x_5-26.25x_6+400x_7+150x_8 \leq 0$$

(Cocoa usage)

$$87.5x_1+35x_2+75x_3+30x_4+50x_5+20x_6+70x_7+12x_8 \leq 100000$$

(Milk usage)

$$62.5x_1+25x_2+50x_3+20x_4+50x_5+20x_6+30x_7+12x_8 \leq 120000$$

(Nuts usage)

$$0x_1+0x_2+37.5x_3+15x_4+75x_5+30x_6+0x_7+0x_8 \leq 60000$$

(Confectionary sugar usage)

$$100x_1+40x_2+87.5x_3+35x_4+75x_5+30x_6+210x_7+24x_8 \leq 200000$$

(Flour usage)

$$0x_1+0x_2+0x_3+0x_4+0x_5+0x_6+0x_7+72x_8 \leq 200000$$

(Aluminum foils usage)

$$500x_1+0x_2+500x_3+0x_4+0x_5+0x_6+0x_7+250x_8 \leq 500000$$

(Paper usage)

$$450x_1+0x_2+450x_3+0x_4+450x_5+0x_6+0x_7+0x_8 \leq 500000$$

(Plastic usage)

$$60x_1+120x_2+60x_3+120x_4+60x_5+120x_6+1600x_7+250x_8 \leq 500000$$

(Cooking facility usage)

$$0.5x_1+0.2x_2+0.425x_3+0.17x_4+0.35x_5+0.14x_6+0.6x_7+0.096x_8 \leq 1000$$

(Mixing facility usage)

$$0x_1+0x_2+0.15x_3+0.06x_4+0.25x_5+0.1x_6+0x_7+0x_8 \leq 200$$

(Forming facility usage)

$$0.75x_1+0.3x_2+0.75x_3+0.3x_4+0.75x_5+0.3x_6+0.9x_7+0.36x_8 \leq 1500$$

(Grinding facility usage)

$$0x_1+0x_2+0.25x_3+0x_4+0x_5+0x_6+0x_7+0x_8 \leq 200$$

(Wafer making facility usage)

$$0x_1+0x_2+0x_3+0x_4+0x_5+0x_6+0x_7+0.3x_8 \leq 100$$

(Cutting facility usage)

$$0.5x_1+0.1x_2+0.1x_3+0.1x_4+0.1x_5+0.1x_6+0.2x_7+0x_8 \leq 400$$

(Packaging facility usage)

$$0.25x_1+0x_2+0.25x_3+0x_4+0.25x_5+0x_6+0x_7+0.1x_8 \leq 400$$

(Packaging 2 facility usage)

$$0.05x_1+0.3x_2+0.05x_3+0.3x_4+0.05x_5+0.3x_6+2.5x_7+0.15x_8 \leq 1000$$

(Labor usage)

$$0.3x_1+0.3x_2+0.05x_3+0.3x_4+0.3x_5+0.3x_6+2.5x_7+0.25x_8 \leq 1000$$

(Demand for MC 250)

$$X_1 \leq 500$$

(Demand for MC 100)

$$X_2 \leq 800$$

(Demand for CC 250)

$$X_3 \leq 400$$

(Demand for CC 100)

$$X_4 \leq 600$$

(Demand for CN 250)

$$X_5 \leq 300$$

(Demand for CN 100)

$$X_6 \leq 500$$

(Demand for candy)

$$X_7 \leq 200$$

(Demand for wafer)

$$X_8 \leq 400$$

The decision variables $X_{1 \ldots} X_8$, $X_{1 \ldots} X_8 \geq 0$.

The revenue and the profit objective functions coefficients are fuzzy parameters.

The Steps of Solving The Modified Chocoman Problem Are as Follows:

Step 1: **T**ransform fuzzy parameters in objective functions to crisp parameters according to **equation (7).**

Step 2: Determine the lower and upper bound for each objective by solving each problem individually as a single objective using package.

Step 3: Use the upper bounds only (if the problem is maximization for all objectives). Then, these upper bound are put them as goals in the R.H.S (b_i) of goal programming model to minimize the deviational variables ($\boldsymbol{d_i^-}$) if the objectives max and ($\boldsymbol{d_i^+}$) if the objectives mini).

Step 4: Solve the final crisp model applying goal programming approach with equal weights using the package reaching to the final optimal **decision variables of $\mathbf{x_i^*}$**

5. Solving The Modified Chocoman Problem

This section discusses the results of modified S-Curve membership function of fuzzy multi-objectives linear programming and then, adding deviational variables of goal programming. Those methods are used for solving the modified Chocoman problem which represents as industrial production planning problem.

After applying **equation (7)** as we illustrated in **(step 1)** to transform fuzzy coefficients in revenue and profit of objective functions to crisp parameters; the model become as follows:

F_1: Revenue

$313x_1+125x_2+334x_3+133x_4+348x_5+145x_6+334x_7+125x_8$

F_2: profit

$150x_1+69x_2+128x_3+60x_4+108x_5+58x_6+174x_7+69x_8$

F_3: market share for chocolate bars

$0.25x_1+0.1x_2+0.25x_3+0.1x_4+0.25x_5+0.1x_6$

F_4: units produced

$x_1+x_2+x_3+x_4+x_5+x_6+x_7+x_8$

F_5: plant utilization

$1.65x_1+0.9x_2+1.975x_3+1.03x_4+1.75x_5+0.94x_6+4.2x_7+1.006x_8$

Subject to

$$s.t \quad \sum_{i=1}^{29}\sum_{j=1}^{8} a_{ij}X_j \le b_i$$

Then, this above model became typical multi-objective linear programming

Table 5.1 The maximum and minimum values of objective functions

Objective function	F_i^{min}	F_i^{max}
F_1	0	508429
F_2	0	220748
F_3	0	357
F_4	0	2826
F_5	0	3519

Table 5.1 illustrates **(as shown before in step 2)** the maximum and minimum values of each objective function to transform them as illustrated in **(step 3)** reaching to the goal programming model with assumption that all objective functions have equal weights. Thus, the goal programming model is as follows:

$$\text{minimize}\, G = d_1^- + d_2^- + d_3^- + d_4^- + d_5^-$$

Subject to

$$F_1 - d_1^+ + d_1^- = 508429 \quad (F_1^{max})$$
$$F_2 - d_2^+ + d_2^- = 220748 \quad (F_2^{max})$$
$$F_3 - d_3^+ + d_3^- = 357 \quad (F_3^{max})$$

$$F_4 - d_4^+ + d_4^- = 2826 \qquad (\boldsymbol{F_4^{max}})$$
$$F_5 - d_5^+ + d_5^- = 3519 \qquad (\boldsymbol{F_5^{max}})$$
$$s.t \qquad \sum_{i=1}^{29}\sum_{j=1}^{8} a_{ij}X_j \le b_i$$

Where $d_1^+, d_1^-, d_2^+, d_2^-, d_3^+, d_3^-, d_4^+, d_4^-, d_5^+, d_5^-$ are deviational variables and must be nonnegative & F_1, F_2, F_3, F_4, F_5 are objective functions, where $X_j \ge 0$.

As shown in **(step 4),** applying WINQSB program (goal programming tool); reaching to the optimal solution as follows:

Table 5.2 The optimal solution of the Chocoman problem

Objective function	Solution values
F_1 (revenue)	508424
F_2 (profit)	215516
F_3 (market share chocolate bars)	329
F_4 (units produced)	1477
F_5 (plant utilization)	3376
Decision variables	**Solution values**
X_1	188
X_2	316
X_3	300
X_4	500
X_5	300
X_6	500
X_7	95
X_8	278

In Table 5.2, the optimal solution of the chocoman problem is obtained and measured. The total revenue (F_1) is **equal to 508424** and this value is almost **100%** of goal No. 1 (F_1^{max}). The total profit (F_2) is **equal to 215516** and this value represents **97.6 %** of goal No. 2 (F_2^{max}).

The goal No. 3 of market share chocolate bars (F_3) is **equal to 329** and this value represents **92 %** of goal of No. 3 (F_3^{max}). The units produced (F_4) is **equal to 2477** and this value is **88 %** of goal of No. 4 (F_4^{max}) and finally, the goal of plant utilization (F_5) is equal to **3376** and this value represents **96 %** of goal No. 5 (F_5^{max}).

6. Conclusion

In this paper, we have a solution to the industrial production planning problem using fuzzy multi-objectives and goal programming approaches in modified Chocoman problem. The modified S-Curve membership function is used to transform fuzzy parameters in coefficients of objective functions to crisp. Then, the new formulation model is found suitable to apply the goal programming approach. This sequence as a methodology to solve the modified Chocoman problem has applied successfully and the comparison with upper boundaries of objective functions appeared satisfactory results.

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Asset Allocation Management to Secure Pension Fund in Fuzzy Environment

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Abstract

Pension fund needs to produce a high-income return correspond to actuarial expectations of different kinds of benefits. An asset allocation management (ALM) model of a pension fund must consider a large planning horizon because of its long-term obligations. ALM controls solvency of the fund by suitable investments and contribution policies to secure the pensioners future liabilities. Financial markets have fuzziness, vagueness and ambiguity variables. Fuzzy numbers given by experts and accepted by decision-makers, provide a powerful tool for describing the fuzzy uncertainty. In this paper, a portfolio optimization model is introduced based on fuzzy variance minimization at a required return level that secures the fund against insolvency risk. This method uses a fuzzy approach to the mean-variance defined by Markowitz so that future returns of the stocks are predicted with help of Triangular Fuzzy Numbers (TFN).

Keywords:

Pension fund; Fuzzy sets; Fuzzy mean and variance; Insolvency risk.

1. Introduction

Pension fund must be periodic evaluated by actuaries and predict annual cash flow of income and liabilities (outcomes). The sponsor of plan take decisions at certain time, as investment decision to decide which assets allocated to attain a return enough to pay the participants’ liabilities. The paper proposes model to assistance the decision maker to take this decision. Depending on earlier works of Markowitz (1952), Dubois and Prade (1987), fuzzy approach Carlsson and Fullër (2001) defined possibilistic mean value, variance and covariance of fuzzy numbers. The paper proposes modify Markowitz model by adding new constraint that responsible for secure the pension fund towards insolvency risk.

Pension funds are becoming fundamental tools in financial markets. Nowadays, pension fund investments represent a considerable percentage of financial market operations. In a general perspective, there are two extremely different ways to manage a pension fund. First, the pension fund can be managed through Defined Benefit (DB) plans, where benefits are fixed in advance by the sponsor and contributions are initially set and subsequently adjusted in order to maintain the fund in balance.

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In other words, DB plan provides a guarantee by the pension plan or government that a pension will be paid based on a certain formula in which contribution may not be tied actually to benefits. Secondly, pension fund can be managed through Defined Contribution (DC) plans, where contributions are fixed and benefits depend on the returns on fund portfolio. In other words, DC plan provides a pension plan in which a periodic contribution is prescribed and the benefit depends on the contribution plus the investment return.

Many papers used the types of pension plans as Boulier et al. (2001), Vigna and Haberman (2001), Haberman and Vigna (2002), Deelstra et al. (2000,2003), Battocchio and Menoncin (2002), call in DC pension funds, Haberman and Sung (1994), Chang (1999), Haberman et al. (2000), Taylor (2002), Chang et al. (2003) and Josa-Fombellida and Rincón-Zapatero (2001,2004), in DB pension funds, and Cairns (2000), in both types of plans. Yufei et al. (2016) they consider the portfolio optimization problem for a pension fund consisting of various government and corporate bonds. And aims maximize the fund's cash position at the end of the time horizon, while allowing for the possibility of bond defaults.

The literature about portfolio selection and pension funding, such as those of Chang (1999), Cairns (2000), Boulier et al. (2001), Josa-Fombellida and Rinc´on Zapatero (2001, 2004, 2006, 2008, 2012, 2017), Chang et al. (2003), Deelstra et al. (2003), Battocchio and Menoncin (2004), Cairns et al. (2006), Xu et al (2007), Delong et al. (2008) and Le Cortois and Menoncin (2015) All previous papers assume that uncertainty variables are geometric Brownian motions. This assumption does not reflect the sometimes observed real financial phenomena.

Josa-Fombellida and Rinc´on-Zapatero (2017) present a differential game between the sponsoring firm and workers' representatives (the union) is studied the objective of the union to maximize the expected discounted utility of the extra benefits claimed on the fund surplus, whereas the firm's objective is to maximize the expected discounted utility of the fund surplus. Zhao and Rong (2017) maximize a power utility function in a portfolio selection problem. Josa-Fombellida and Rinc´on-Zapatero (2018), study the optimal asset allocation problem of a DB pension plan that operates in a financial market composed of risky assets whose prices are constant elasticity variance processes (CEV).

Markowitz specified the trade-off facing the investor: risk versus expected return. The investment decisions are not simply which securities to own, but how to divide the investor's wealth amongst them. This is problem called "Portfolio Selection" hence the title of Markowitz's seminal article published in the 1952 issue of the Journal of Finance. He identifies all feasible portfolios that minimize risk (as measured by variance or standard deviation) for a certain level of expected return and maximize expected return for a certain level of risk.

In fuzzy environment this article modifies Markowitz's model by adding new constraint that responsible for secure the pension fund against insolvency risk i.e. ability for cover all participant's liabilities along horizon where the return is TFN.

This paper is organized as follows. In Section 2, shows important definitions are useful for the problem. In section 3, shows proposed model for the problem. In section 4, numerical example to illustrate the proposed model. And finally, Section 6 presents a conclusion.

2. Definitions

Definition 1 (Carlsson and Fuller, 2001) A fuzzy number A is a fuzzy set of the real line R with a normal fuzzy convex and continuous membership function of bounded support. The family of fuzzy numbers will be denoted by F. A γ-level set of a fuzzy number A is defined by $[A]^\gamma = \{t \in R \mid A(t) \geq \gamma\}$ if $\gamma > 0$ and $[A]^\gamma = cl\{t \in R \mid A(t) > 0\}$ (the closure of the support of A) if $\gamma = 0$. It is well known that if A is a fuzzy number then $[A]^\gamma$ is a compact subset of R for all $\gamma \in [0; 1]$.
A fuzzy number A is called a triangular fuzzy number (TFN) with peak (or center) r, left width b > 0 and right width c > 0 if its membership function has the following form:

$$\mu(x) = \begin{cases} \dfrac{b + x - r}{b}, & r - b \leq x < r \\ \dfrac{c - x + r}{c}, & r \leq x < r + c \\ 0, & \text{otherwise} \end{cases}$$

We use notation A = (r, b, c), the support of a TFN A is (r - b, r + c) with center r can be considered as "x is approximately equal to r".
If b = c then we call TFN symmetrical, and refer to it as (r, b).
Let A = (a, α) and B = (b, β) be two symmetrical TFNs. Then

$$A + B = (a + b, \alpha + \beta); \qquad \lambda A = (\lambda a, |\lambda|\alpha)$$

Let apply to a TFN R= (r, b, c) with center r, left width b>0 and right width c > 0 as depicted in Fig.1

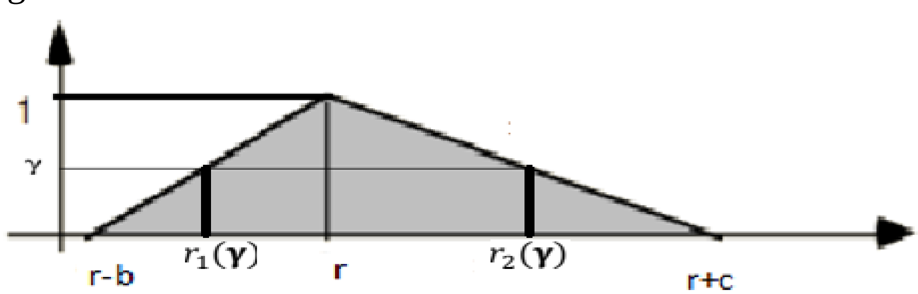

Fig. 1 Triangular fuzzy number (r, b, c) with center r and presentation of $r_1(\gamma)$ and $r_2(\gamma)$

Because of $r_1(\gamma)$ and $r_2(\gamma)$ have linear nature then by using simple mathematic rules can obtain:

$$r_1(\gamma) = r - (1-\gamma)b; \quad r_2(\gamma) = r + (1-\gamma)c; \quad \gamma \in [0.1]$$

Definition 2 (Carlsson, Fuller ,2001) the possibilistic mean value of a fuzzy number Let R be a fuzzy number with γ level set [R]γ = $[R_1(\gamma), R_2(\gamma)]$; (γ > 0). So the possibilistic mean value of fuzzy numbers is as below:

$$M(R) = \int_0^1 (R_1(\gamma) + R_2(\gamma))\gamma d\gamma = \frac{\int_0^1 \frac{(R_1(\gamma) + R_2(\gamma))}{2}\gamma d\gamma}{\int_0^1 \gamma d\gamma} \qquad (1)$$

It follows that M(R) is nothing else but the level-weighted average of the arithmetic means of all γ level sets, that is, the weight of the arithmetic mean of $R_1(\gamma)$ and $R_2(\gamma)$ is just γ.

Definition 3 (Carlsson, Fuller, 2001) the possibilistic variance of a fuzzy number

$$Var(R) = Cov(R, R) = \frac{1}{6}\int_0^1 (R_2(\boldsymbol{\gamma}) - R_1(\boldsymbol{\gamma}))^2 \boldsymbol{\gamma} d\boldsymbol{\gamma} \qquad (2)$$

Let $R_1(\boldsymbol{\gamma})$ and $R_2(\boldsymbol{\gamma})$ are linear functions applied to TFN R=(r, b, c) with center r. **Guran C. et al. (2015)** proved that possibilistic mean and variance of TFN R=(r, b, c) is calculated after a few integral calculations as below

$$M(R) = r + \frac{(c - b)}{6} \qquad (3)$$

$$Var(R) = \frac{(b + c)^2}{24} \qquad (4)$$

Definition 4 (Carlsson, Fuller, 2001) Let R and W are fuzzy numbers. Then their **fuzzy covariance** is defined as:

Where [R]γ = $[r_1(\boldsymbol{\gamma}), r_2(\boldsymbol{\gamma})]$ and [W]γ = $[w_2(\boldsymbol{\gamma}), w_2(\boldsymbol{\gamma})]$; (γ > 0) then possibilistic covariance of R and W defined as below:

$$Cov(R, w) = \frac{1}{2}\int_0^1 \left(r_2(\gamma) - r_1(\gamma)\right)\left(w_2(\gamma) - w_1(\gamma)\right)\gamma d\gamma \qquad (5)$$

When R=(r, b, c) and W= (w, θ, λ) are TFNs then the related functions become as below respectively:

$$r_1(\boldsymbol{\gamma}) = r - (1-\boldsymbol{\gamma})b;\ r_2(\boldsymbol{\gamma}) = r + (1-\boldsymbol{\gamma})c;$$

$$w_1(\boldsymbol{\gamma}) = w - (1-\boldsymbol{\gamma})\theta;\ w_2(\boldsymbol{\gamma}) = w + (1-\boldsymbol{\gamma})\lambda$$

Then Guran C. et al. (2015) proved that Cov(R,W) calculated as below:

$$Cov(R, W) = \frac{(b + c)(\boldsymbol{\theta} + \boldsymbol{\lambda})}{24} \qquad (6)$$

Notice that if R=W =(r, b, c) then the covariance become Cov(R,R) = $\frac{(b + c)^2}{24}$ which is the variance of TFN R.

Theorem: (Carlsson, Fuller, 2001) Let λ; μ ∈ R and let A and B be fuzzy numbers. Then

$$\text{Var}(\lambda A + \mu B) = \lambda^2 \text{ Var}(A) + \mu^2 \text{ Var}(B) + 2|\lambda\mu| \text{ Cov}(A, B)$$

Where addition and multiplication operations by a scalar of fuzzy numbers is defined by the sup-min extension principle.

Carlsson and Fullër (2001) proved this theorem which forms the fundamental of the portfolio variance in fuzzy environment. By generalized this theorem is to n fuzzy numbers R_1 , ….... , R_n with constants λ_1,……., λ_n ∈ R, the result can be obtained as:

$$\text{Var}(\lambda_1 R_1 + \lambda_2 R_2 + \cdots \dots \dots \dots . + \lambda_n R_n) =$$
$$\lambda_1^2 \text{ Var}(R_1) + \lambda_2^2 \text{ Var}(R_2) + \dots\dots + \lambda_n^2 \text{ Var}(R_n) + 2| \lambda_1 \lambda_2| \text{ Cov}(R_1,R_2) + \dots\dots\dots\dots +$$
$$2| \lambda_{n-1} \lambda_n| \text{ Cov}(R_{n-1}, R_n) =$$
$$\sum_{i=1}^{n} \lambda_i^2 \text{ Var}(R_i) + 2\sum_{i\neq j=1}^{n} |\lambda_i\lambda_j| \text{Cov}(R_i, R_j) \qquad (7)$$

Markowitz's model:

$$\textbf{Min} \quad \text{Var}(R_p)$$

Subject to

$$\text{E}(R_p) \geq \boldsymbol{K} ;$$
$$\sum_{i=1}^{n} x_i = 1 ;$$
$$x_i \geq 0 ;$$

where

$\text{E}(R_p)$: the expected portfolio return, $\text{E}(R_p) = \sum_{i=1}^{n} x_i \text{ E}(R_i)$

$\text{Var}(R_p)$: The variance of portfolio,

$$\text{Var}(R_p) = \sum_{i=1}^{n} x_i^2 \text{ var}(R_i) + 2\sum_{i\neq j=1}^{n} x_i x_j \text{Cov}(R_i, R_j)$$

$\text{Cov}(R_i, R_j)$: The covariance of returns R_i and R_j

x_i : is money allocated percentage at asset i

$\boldsymbol{K}$: certain return

3. Proposed model

Let the portfolio consisting of **n** assets and operating over next time of one period, **M** denotes the fund's cash level at the start of the period, $\widetilde{R}_i$ denote the fuzzy return at the end of this period, **P** denote the total pension payments plus all additive payments related the plan to be made during this period and **C** denote the contribution to be made during this period obtained by actuaries. Hence we can write the proposed model as

$$\text{Min} \quad \text{Var}(\widetilde{R}_P) = \sum_{i=1}^{n} \text{var}(\widetilde{R}_i)\, x_i^2 + 2 \sum_{j\neq i=1}^{n} \text{cov}(\widetilde{R}_i ; \widetilde{R}_j)\, x_i\, x_j$$

Subject to

$$\text{E}(\widetilde{R}_P) = \sum_{i=1}^{n} \text{E}(\widetilde{R}_i) * x_i \geq \boldsymbol{K} ;$$
$$(1+ \text{E}(\widetilde{R}_P))*(M) + C - P \geq 0; \qquad \text{(insolvency risk)}$$
$$\sum_{i=1}^{n} x_i = 1 ;$$
$$x_i \geq 0; \quad i=1,2,\dots\dots,n \qquad \text{(Short sell not allowed)}$$

Where

$E(\tilde{R}_P)$: Expectation of fuzzy return of portfolio

$V(\tilde{R}_P)$: Variance of fuzzy return (risk) of portfolio

K : Required return satisfied the balance in pension plan and secures the fund against insolvency

$cov(\tilde{R}_{i\,;}\tilde{R}_j)$: Covariance between fuzzy returns of assets i,j

M: Fund's reserve of pension plan

C: Contributions paid by scheme's participants

P: Grantees benefits paid by pension scheme plus all administrative expenses

x_i: Proportion at assets i

The adding constraint $(1+ E(\tilde{R}_P))*(M) + C - P \geq 0$ in detail :

This constraint meaning that all money in the fund (M) at start of period after investment optimization i.e. $(1+ E(\tilde{R}_P))*(M)$ plus yearly contributions (C) must be cover all liabilities plus all administrative expenses (P).

The optimized portfolio is found by minimizing the fuzzy variance (risk) for a certain target return level that reserve the pension fund from insolvency risk. This return level is determined by actuary' mathematics rules.

In terms of fuzzy logic, triangular membership functions are used to forecast future returns both because of its suitable nature to the portfolio selection problem and because of its linear structure which facilitates the optimization model.

Now, predict the future return of an asset, assume the membership degree of the fuzzy average is always 1. But the membership degrees will change depending on the scenario whilst deviating vastly from the fuzzy average.

The triangular membership function representing the future returns r_i of the i^{th} asset where i ∈ {1, 2,…....., n}:-

$$\mu_i(x) = \begin{cases} \dfrac{x + b_i - r_i}{b_i}, & r_i - b_i \leq x \leq r_i \\ \dfrac{c_i - x + r_i}{c_i}, & r_i \leq x \leq r_i + c_i \\ 0 \quad , & \text{otherwise} \end{cases}$$

This triangular membership function can be expressed by $(r_i - b_i, r_i\ , r_i + c_i)$ where b_i and c_i represent maximum possible differences of future returns respectively in down and up directions and r_i is the expected center future return with the highest membership value of 1. After the calculation of r_i, b_i and c_i values of each asset, the fuzzy mean value of the whole portfolio return of n assets can be defined as:

$$M(r) = \sum_{i=1}^{n} M(r_i)x_i \qquad ; i =1,…….., n$$

Where x_i represents the proportion of money invested in the i^{th} asset. These proportions satisfy that short selling of any stock is not allowed in the proposed models i.e. $\sum_{i=1}^{n} x_i = 1$; i =1,…….., n

Where the return of i^{th} asset can expressed as (r_i, b_i, c_i) Since r_i is the midpoint of TFN then by eq. 3 we can write the return of i^{th} asset as :

$$M(r_i) = r_i + \frac{(c_i - b_i)}{6}$$

Then the fuzzy mean value of the whole portfolio return of **n** assets as:

$$M(r) = \sum_{i=1}^{n}(r_i + \frac{(c_i - b_i)}{6})\, x_i \;;\quad i = 1,\ldots\ldots, n$$

And according to the model we must define the variance and the covariance for the portfolio as previous method in fuzzy mean value.
As aforementioned the fuzzy variance of the whole portfolio Var(r) equal:

$$\sum_{i=1}^{n} x_i^2 \operatorname{Var}(r_i) + 2\sum_{i\neq j=1}^{n} |x_i x_j| \operatorname{Cov}(r_i, r_j)$$

Guran C. et al. (2015) proved that Var(r) as (**called fuzzy variance of the portfolio**):

$$\operatorname{Var}(r) = \sum_{i=1}^{n} \frac{(b_i + c_i)^2}{24} x_i^2 + 2\sum_{i\neq j=1}^{n} \frac{(b_i + c_i)(b_j + c_j)}{24} x_i x_j = \left(\sum_{i=1}^{n} \frac{b_i + c_i}{2\sqrt{6}} x_i\right)^2$$

And they said "***To facilitate the solution of this optimization model, standard deviation can be used instead of variance the risk of portfolio can be the square root of Var(r) and obtained as*** $\sqrt{\left(\sum_{i=1}^{n} \frac{b_i + c_i}{2\sqrt{6}} x_i\right)^2} = \sum_{i=1}^{n} \frac{b_i + c_i}{2\sqrt{6}} x_i$

When defuzzified standard deviation is minimized instead of fuzzy variance, the model is transformed to a linear optimization model as below:

$$\boldsymbol{Min\ \sqrt{Var(r)} = \sum_{i=1}^{n} \frac{b_i + c_i}{2\sqrt{6}} x_i}$$

Subject to

$$\boldsymbol{\sum_{i=1}^{n}(r_i + \frac{(c_i - b_i)}{6})\, x_i \geq K\ ;}$$
$$\boldsymbol{\sum_{i=1}^{n} x_i = 1\ ;}$$
$$\boldsymbol{x_i \geq 0};$$
$$\boldsymbol{0 \leq x_i \leq 1;\quad i=1,2,\ldots,n}$$ "

Then the proposed model is transformed to a linear optimization model as below:

$$\text{Min } \sqrt{\operatorname{Var}(r)} = \sum_{i=1}^{n} \frac{b_i + c_i}{2\sqrt{6}} x_i$$

Subject to

$$\sum_{i=1}^{n}(r_i + \frac{(c_i - b_i)}{6})\, x_i \geq \boldsymbol{K}\ ;$$
$$(1 + \sum_{i=1}^{n}(r_i + \frac{(c_i - b_i)}{6})\, x_i) * M + C - P \geq 0\ ; \quad \text{(insolvency risk)}$$
$$\sum_{i=1}^{n} x_i = 1\ ;$$
$$x_i \geq 0; \qquad \text{(Short sell not allowed)}$$

This linear optimization model, $\boldsymbol{K}$ represents the desired minimum portfolio return level and its value determine by actuaries that satisfy balance the pension fund. It is clear that the greater the return, the greater the size of the portfolio risk. On the contrary this not required where the main objective that secures future participant's liabilities and their beneficiaries not have dividends only.

By using alternatives of software programs for solve the model after we determine the required return secure pension fund against insolvency risk.

4. Numerical example to illustrate the model

We can evaluate participants of some Egyptian funds at 30/9/2018 and its data and results as following steps:

Step 1: determine the required rate of return secure the fund and collecting data as:

M (reserve of pension fund at start year) = 378600936 L. E.;

$\boldsymbol{K}(\text{the required rate of return secure the fund}) = 0.15$

P (all expected liabilities at first year) = 85 602 539;

C (expected contribution at first year) = 47 289 513;

The actuary's results:

Table 1. Cash flow for the expected liabilities and contributions

Years	Income	All liabilities
0	47 289 513	85 602 539
1	47 804 241	80 788 060
2	47 797 294	100 910 079
3	47 449 742	107 330 383
4	48 089 326	82 210 994

Table 1 illustrate the promised benefits for the participants and their future contributions, from the evaluation's results sponsor's decisions should be invest the surplus to attain the required rate of return to satisfy fund's balance.

In this part we can point to the case study Egyptian Stock Exchange (EGX). Table 2 shows these stocks. All data in this table consisting of the closing values of six stocks from 10.2012 to 10.2018 are taken from the official web site of Egyptian Stock Exchange, mubasher.com, on a yearly basis total of 7 observation periods

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Table2. Closed market value of the assets

	Assets					
date	EPPK	EXPA	ELEC	VODE	FAIT	ACRO
10/2018	8.41	8.71	0.90	120.00	14.02	25.78
10/2017	5.17	11.98	1.02	73.12	17.17	27.31
10/2016	2.94	6.65	0.72	66.23	5.25	10.75
10/2015	6.61	7.96	0.87	35.55	4.03	13.39
10/2014	7.46	6.71	1.21	80.06	4.40	8.86
10/2013	4.93	5.72	0.71	69.11	4.73	8.67
10/2012	4.54	5.04	0.80	86.90	4.12	4.15

Table 3. The returns of the assets

	Assets					
date	EPPK	EXPA	ELEC	VODE	FAIT	ACRO
10/2018	3.24	-3.27	-0.12	46.88	-3.15	-1.53
10/2017	2.23	5.33	0.30	6.89	11.92	16.56
10/2016	-3.67	-1.31	-0.15	30.68	1.22	-2.64
10/2015	-0.85	1.25	-0.34	-44.51	-0.37	4.53
10/2014	2.53	0.99	0.50	10.95	-0.33	0.19
10/2013	0.39	0.68	-0.09	-17.79	0.61	4.52

Table 3 show the return's values of these six stocks by changes in their closed values as observations along 7 years.

Table 4. the rate of return of assets

	Assets					
date	EPPK	EXPA	ELEC	VODE	FAIT	ACRO
10/2018	0.63	-0.27	-0.12	0.64	-0.18	-0.06
10/2017	0.76	0.80	0.42	0.10	2.27	1.54
10/2016	-0.56	-0.16	-0.17	0.86	0.30	-0.20
10/2015	-0.11	0.19	-0.28	-0.56	-0.08	0.51
10/2014	0.51	0.17	0.70	0.16	-0.07	0.02
10/2013	0.09	0.13	-0.11	-0.20	0.15	1.09

Table 4 show the return's rates of this six stocks by dividing their values on closed market values of each stock as observations along 7 years.

Step 2: By some calculations we can obtain the next parameters:

Table 5. The parameters that used in the model (r_i's , b_i's, c_i's)

assets	EPPK	EXPA	ELEC	VODE	FAIT	ACRO
r_i	**0.22**	**0.14**	**0.07**	**0.17**	**0.40**	**0.48**
b_i	**0.77**	**0.42**	**0.35**	**0.72**	**0.58**	**0.68**
c_i	**0.54**	**0.66**	**0.63**	**0.70**	**1.87**	**1.06**

Table 5 illustrates the necessary calculations of the EGX efficient 6 stocks in order to apply the optimization model.

The proposed model is applied to the 6 stocks. First of all, we should be determining the membership function displaying the future return for each of these 6 stocks. To determine these functions, it is trivially to compute the expected center future return (r_i) since it can be accepted as the average return of the stock where i=1,…, 6. But there is not just a certain rule to estimate the up direction (b_i) and the down direction (c_i) representing the maximum possible differences of future returns. Actually these deviations reflect the expert knowledge. That means this fuzzy model enables that up and down directions can be determined according to the next coming economic conditions i.e. the actuaries can determine this values by experts. But this example, the past observations of the stocks in the last 7 years are observed and under the lights of this information (c_i) and (b_i) are determined due to relatively the best and the worst returns in the past. So the proposed model for this problem as:

$$\textbf{Min } \sqrt{\mathbf{Var(r)}} = \sum_{i=1}^{6} \frac{b_i + c_i}{2\sqrt{6}} \mathbf{x_i}$$

Subject to

$$\sum_{i=1}^{6} \left(\mathbf{r_i} + \frac{(\mathbf{c_i} - \mathbf{b_i})}{6}\right) \mathbf{x_i} \geq \boldsymbol{K} ;$$

$$\left(1 + \sum_{i=1}^{6} \left(\mathbf{r_i} + \frac{(\mathbf{c_i} - \mathbf{b_i})}{6}\right) \mathbf{x_i}\right) * \mathbf{M} + \mathbf{C} - \mathbf{P} \geq \mathbf{0} ; \quad \textbf{(insolvency risk)}$$

$$\sum_{i=1}^{6} \mathbf{x_i} = \mathbf{1} ;$$

$$\mathbf{x_i} \geq \mathbf{0}; \quad \mathbf{i=1, 2, 3, 4, 5, 6} \quad \textbf{(Short sell not allowed)}$$

Step 3: write model code and have results.

The optimal allocation for the reserve of pension fund to secure the fund and reserve the balance for the pension's plan for the six assets is:-

- Money allocates in asset EXPA = .4798 * 378600936 = 181 652 729L. E

- Money allocates in asset ELEC = .5202 * 378600936 = 196 948 207L. E

Then sponsor's objectives are occur where risk (standard deviation) is minimized which is objective function and equal 0.2098.

5. Conclusion

We have analyzed the management of a pension funding process of a DB pension plan when the short interest rate is the yearly model. Yearly insolvency risk may be solved analytically when the benefits process is a determined under a suitable selection of the technical interest rate and actuary determine the required return rate that does not expose pension fund to insolvency risk.

The components of the optimal portfolio investments in risky and riskless assets are the sum of all terms, and face the actuarial liability, depending on parameters of the randomness of benefits, all expenses and contributions where interest rate is TFN.

We have done a case study of the pension fund and have all required data to show some properties of the model. The decision maker would check the fund's finance status every short certain period.

A portfolio optimization method which minimizes the fuzzy variance of the portfolio is introduced and this method is applied to the 6 well known stocks of Egypt Stock Market. With its fuzzy background this method has some serious advantages compared to the classical MV optimization which is introduced by Markowitz 66 years ago. Firstly, the required return for balance of pension's fund can check short certain period and can reallocate if the required not satisfied. Secondly, the portfolio managers can add their subjective opinions to the model with the help of triangular fuzzy numbers representing the future returns of the stocks. Thirdly, the model carries computation simplicity of the character of the used membership functions. Forth, this method does not require the limitations of classical MV optimization which are listed in detail of the classical MV optimization.

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A Dynamic Model for Sustainable Water Resources Management in Egypt

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Abstract

This work developed a system dynamics model to simulate and analyze the future potential state of water resources in Egypt. The developed model illustrates the concept of water resources availability and needs through the use of causal loop diagrams, stock and flow diagrams, equations, and simulation output graphs. This model shows the feedback and interactions between different variables of the water system. Multi-temporal data were collected to study the dynamic changes in water resources. The developed model will be the base for a decision support tool that enables policymakers to investigate water resources problem in Egypt and achieve the optimal allocation of limited water resources. Also, this work allows long period predictions, which are not available in other published research. The results showed that population growth and agricultural needs are the main factors causing the water crisis in Egypt. They also illustrated that the water needs exceed water availability. In addition, maximizing the utilization of the agricultural drainage water will contribute to reducing this gap.

Keywords: **Simulation Modeling; System Dynamics; Water Adequacy Index; Egypt; Powersim**

1. Introduction

Water is the most vital natural resource on Earth after air where its quantities almost constant. It is essential to humans, plants, and animals to keep alive. In addition, it is important for the ecological balance of the earth. It covers 71% of the Earth's surface. Also, it frames 75% and 80% of human body weight and total composition of most vegetables respectively. Moreover, water shortage or pollution cause 80% of diseases pervasive all over the world. Thus, water needs and the development process are inseparable, as the quantity of water used per day indicates human civilization and progress (State Information Service, 2017).

Nowadays water severe scarcity is a global concern and it is alarming for the future. On the demand side, the rapid growth of population and the fast development of economy worldwide have compelled on a higher water demand. On the supply side, less predictable rainfall due to climate change causes less reliability of water natural sources (Xi and Poh, 2013).

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Sustainable water management needs innovative practices of water management, to balance the different water sectors, meanwhile to provide a good quality and sufficient water in the present and future (Xi and Poh, 2013).

Water is the backbone for sustainable and integrated development in Egypt. Water resources in Egypt are the quota of Nile water, the limit amount of rainfall, underground water, and desalination of sea water and drainage water. The water demand has duplicated as a result of population growth, agricultural extension, tourist uses as well as industrial development and a rise in the standard of living. Egypt's share of Nile water is 55.5 billion cubic meters (BCM) represents 95% of Egypt's total amount of water. Egypt highly depends on Nile water because the rainfall is rare. The per capita share of water in Egypt is 690 cubic meters which is below the water poverty line (1000 cubic meters) (Ministry of Water Resources and Irrigation (MWRI), 2013, P.22). It is going to be reduced in the coming years as a result of the increasing population.

In coming years, Egypt will suffer from serious water shortage and water quality degradation, which results from the population growth and the economic and agricultural expansion. Moreover, disputes about the share of each Nile basin state in water and building Grand Ethiopian Renaissance dam (Millennium dam) increase water crisis (Soliman et al., 2016; MIT's Abdul Latif Jameel World Water and Food Security Lab, 2014; Amer, 2013; Telegraph foreign-staff, 2017). Thus, the officials of water resources management in Egypt need to know the optimal allocation of limited water resources.

"System dynamics (SD) is a powerful methodology and computer simulation modeling technique for framing, understanding, and discussing complex issues and problems" (Radzicki and Taylor, 1997). This approach was innovated by Prof. J. W. Forrester in the Massachusetts Institute of Technology (MIT) in 1956. The benefit of this methodology is that it simplifies the study of a complex system over time. Particularly, it deals very well with the interrelationship between variables and time delays that influence the behavior of the whole system. SD has been well applied to study water and natural resources management, economic growth, demographics, energy systems, business development, environmental systems, and other social systems.

This research aims to develop a dynamic simulation model of water resources in Egypt using system dynamics technique tool. The model defines, analyses and describes water resources in terms of feedback loops and stock and flow diagrams. By identifying the interrelationship between different factors, this model can better serve the analysis of the problem. This model enables decision makers to investigate water resources problem in Egypt and achieve the optimal allocation of limited water resources using multi-temporal data. Finally, such knowledge, related to water, would be obtained by a simple way and with dynamic manner.

This paper is organized as follows: section 2 presents “Literature review”. Section 3 introduces “Methodology” which includes these subsections “Simulation modeling”, “Problem definition”, “Data collection”, “Mental model”, and “Stock & flow diagram”. The model results are presented in section 4. The simulation model is then validated as shown in section 5. Finally, section 6 shows “Conclusion”.

2. Literature review

The modeling of water resources that can serve as a decision support system tool is very important in the planning and management of water within the boundaries of states and abroad. It can support the analysis and evaluations of projects concerning with water resources, where it is useful in visualizing and predicting the changes in water supply and demand over the time. Modeling of sustainable water resources management can be conducted by different methods; such as using System Dynamic Simulation Modeling (Xi and Poh, (2013); Adamowski and Halbe, (2011); Zhang et al., (2009); Duran-Encalada et al., 2017; Kotir et al., 2016), Expert Knowledge (Safavi et al., 2015), Fuzzy Logic (Sharma et al., 2012; Raju and Kumar, 2003), Mathematical Programming (Afify, 2010; Georgakakos, 2012; Anyata et al., 2014; Abdel Gawad et al., 1995), the Geographic Information System (GIS) and Remote Sensing (Guo et al., 2010).

Xi and Poh (2013) developed an SD model called Singapore Water to demonstrate that SD is a powerful decision support technique to help achieve sustainable water resource management in Singapore. Zhang et al. (2009) developed a dynamic model based on water resources carrying capacity theory for water resource management using the SD technique.

Sharma et al. (2012) used the fuzzy logic technique in water management system to study Pawana River water quality in linguistic terms. Raju and Kumar (2003) employed fuzzy logic based multicriteria decision making for selecting the best alternative of irrigation subsystem. The performance criteria (indicators) are the conjunctive use of surface and groundwater resources, environmental impact, the participation of farmers, social impact, productivity, and economic impact. These criteria are evaluated for four irrigation subsystems of the Sri Ram Sagar Project, Andhra Pradesh, India to select the best among them.

Afify (2010) used Multi-criteria Decision Analysis for ranking and selection among all possible desalination alternatives for Egypt, considering the consumption of desalinated water, sites of the plants, and their capacities, source of feed water, and desalination technology. Georgakakos (2012) used linear programming to formulate the objective functions and constraints of water allocation problem to assist Castaic Lake Water Agency with decisions to meet annual water demands. Anyata et al. (2014) applied a mathematical model of discrete dynamic programming problem to predict the demand, consumption and net benefit of the conjunctive use of the surface water and groundwater resources at the University of Benin, Benin City, Edo state, Nigeria.

Drainage Research Institute in Egypt developed the Simulation of Water Management in the Arab Republic of Egypt (SIWARE) model as a decision support system to show the impacts of changes in the agricultural water management in three parts of Nile Delta (Western, Middle, and Eastern Delta) (Abdel Gawad et al., 1995). SIWARE is an integrated mathematical and continuous time model based on real physics. Until now, there are no published investigations in using SD as a decision support technique to study the Egyptian's sustainable water resources management.

Zaghloul et al. (2012) conducted a study to address the current and projected availability of Egyptian water needs and water resources. In their study, familiar Statistical methods were used based on Egyptian Water Resources and Irrigation Ministry data, and various sources involved in this field such as National water research center. This study expected that Egyptian water needs reach about 86.18 billion m3 in the year 2025, whereas the total water resources is expected to be in 2025 about 76.86 billion m3.

This paper develops a subsystem diagram of water resources management in Egypt based on previous researchers, studies and experts, mainly (Zhang et al., 2009), (Xi and Poh, 2013) and (MWRI, 2013). The configuration of this subsystem involves 4 major subsystems and minor 7 subsystems as shown in Figure 1. The major subsystems are water demand, water supply, water uses and water surplus/shortage. Water demand determines the quantity of water that Egypt needs per year. Water supply determines the quantity of water available annually. Water uses defines the amount of water uses yearly. Finally, water surplus/shortage shows the abundance or deficits of water per year. When there are some deficits in water, the government should increase the funding for the water sector to build more wastewater and desalination water plants. Also, the increase in GDP leads to an increase in the economic activities and standard of living, thus increasing the water demands.

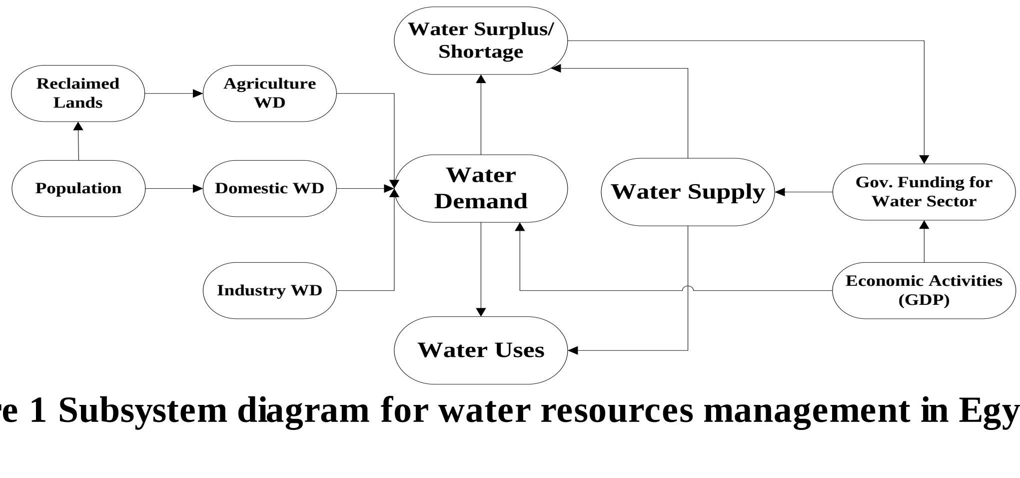


Figure 1 Subsystem diagram for water resources management in Egypt.

The main five differences between this research and the previous work on water resources management in Egypt are the following:

1- This research uses the system dynamics method for developing a dynamic simulation model of water resources in Egypt, which has not been implemented to study the Egyptian's sustainable water resources management before. The SD approach shows the big picture of any problem and highlights its main feedback loops, i.e. SD is a comprehensive and holistic approach to problem-solving.

2- The SD model identifies the interrelationship between different factors (such as the effect of economic activities on population, the standard of living on water demand, and the demand of land reclamation on water demand of the agriculture). The literature does not indicate clearly the relationships among the factors influencing water resource management in Egypt. Identifying these factors and their interrelationships contribute to raising awareness of determining the dimensions of the investigated problem and predicting the future water needs and realistic availability of water in the long term.

3- This research combines water resources, water needs, and water uses in feedback loops, while other researches do not have these feedbacks.

4- This model enables decision makers to investigate water resources problem in Egypt and achieve the optimal allocation of limited water resources using multi-temporal data.

5- In this work, we made forecasts till the year 2035, which are not available in other published research.

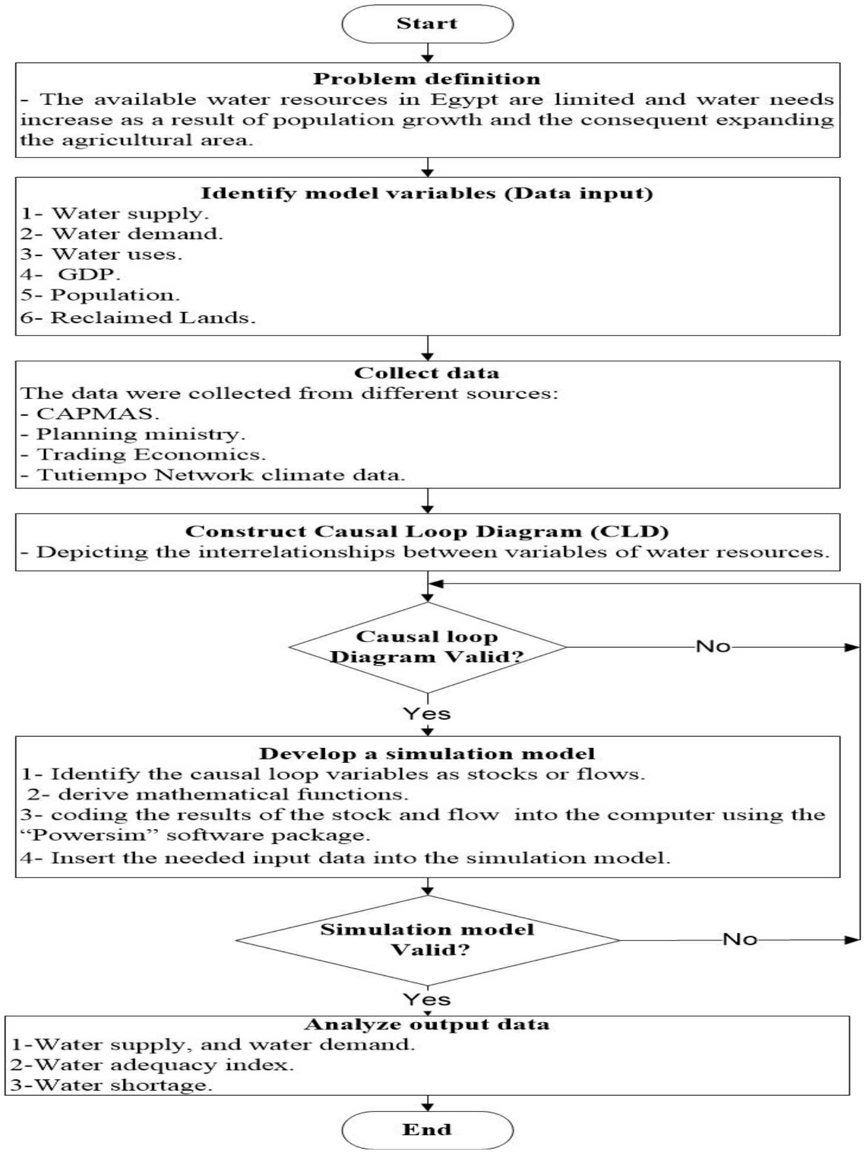
3. Methodology

3.1 Simulation modeling

The developed model is a dynamic model for sustainable water resource management in Egypt. The authors use the system dynamic modeling software "Powersim" for developing the model. It is simulation software based on the system dynamics technique for providing the modelers with higher capabilities to make complex business simulators. Flowchart 1 shows proposed methodology of building a dynamic simulation model of water resources in Egypt. The presented model applies SD as a decision support tool to help achieve sustainable water management in Egypt and analyze the long-term impacts of various investment plans. In addition, the model presents the feedback between various variables.

3.2 Problem definition

The most critical stage in building a model is the problem articulation. What is the issue the participants or users are most worried about? What are the problem and the purpose of the model? Before defining the problem, the authors made twenty-two interviews with twenty individuals of stakeholders who are involved in water resources problems in Egypt. The interviewees represented different organizations, including MWRI, National Water Research Center (NWRC), the National Authority for Remote Sensing and Space Sciences (NARSS), and a number of farmers and citizens. They are decision makers, researchers, farmers or citizens. The authors choose the MWRI because of its responsibility of water resources and irrigation. NWRC was chosen because it is considered the large research center in the water field. The authors also selected NARSS as it is one of the largest research centers in Egypt where water is one of the main research areas. In addition, they selected farmers because they are an essential element involved in water resources problem, where they use a large amount of water to irrigate their lands.



Flowchart 1 A proposed methodology of building a dynamic simulation model of water resources in Egypt

In these interviews, the authors initially gave the stakeholders an overview of their study to enable them to share ideas and information. The stakeholders gave some advice, information and some references to know the problem deeply. Through these interviews, the authors were able to reach a good definition to the problem of water in Egypt, where the available water resources are limited and water needs increase as a result of population growth and the consequent expanding the agricultural area. Based on these interviews, we have identified variables that influence water resources management in Egypt.

3.3 Data collection

With reference to the result of the identified factors, the data required was collected from the year 2004 to 2015. The data were collected from different sources (e.g. Central Agency for Public Mobilization and Statistics (CAPMAS), 2009-2017, (2013); Planning ministry, (2016); Trading Economics, (2016)). For example, Supply and demand water were collected from (CAPMAS, 2009-2017), climatic data such as rainfall and potential evapotranspiration were gathered from (Tutiempo Network climate data, 2016), GDP from (Trading Economics, 2016).

Also, because of limited information and the lack of official data for some variables, presumptions have to be made during model building. The primary assumption is the agriculture water demand is 10% higher than the known agriculture water uses. Secondly, due to some variables change slightly over time, we assume that they are constant during model set up (i.e. rainfall amount, underground water and desalination water).

Statistical analysis was carried out on the collected historical data to get equations that well represent changes in exogenous variables over time (The model equations were illustrated in appendix A).

3.4 Mental model (Causal loop diagram)

The causal loop diagram (CLD) is a significant tool for depicting the interrelationships between variables of water resources. The pool of variables, used in developing the casual loop diagram and stock and flow diagram, were deduced from previous researches, studies, and Experts (Xi and Poh, 2013; Adamowski and Halbe, 2011; Zhang et al., 2009, Ministry of Water Resources and Irrigation, 2005; Koca et al., 2012; Sharawat et al., 2014). The presented causal loop diagram is made of total 23 variables, which are mainly classified into water supply, water demand, water withdrawal, water surplus, and water shortage categories.

After making the causal loop diagram, the authors showed them to three persons of stakeholders from different organizations to know their opinions and validating the causal loop diagram. These stakeholders are researchers and experts at NWRC and NARSS who worked in the water field and share in the national and international project. The authors helped them to understand system dynamic and

CLD by giving them an overview and an example so that they could express their opinions. The opinions of expert professors and researchers are valued and the best way to validate the CLD. After meeting the interviewees, the authors incorporated their inputs and comments in the causal loop diagram. Figures 2-5 depicts the causal and loop diagrams of the model.

Positive/negative signs related to each arrow represent relationships between variables in the CLD. The arrows clarify effect directions while the signs at the end of the arrows are effect signs. A positive sign indicates that both variables change in the same direction. For example, as shown in Figure 2, the interaction between population variable and water demand of domestic uses variable has a positive sign. Thus, the increase of population leads to increasing water Demand for domestic uses. And vice versa, for example, the negative sign interaction between water demand variable and water adequacy index variable presented in Figure 2, where the increase of water demand leads to the decrease in water adequacy index. Furthermore, to form a loop; at least two variables having the same direction are needed. If the loop only has a positive sign or even number of negative signs then it is called a reinforcing (positive) loop as shown in Figures 2, 3. Otherwise, it is called a balancing (negative) loop as presented in Figure 5.

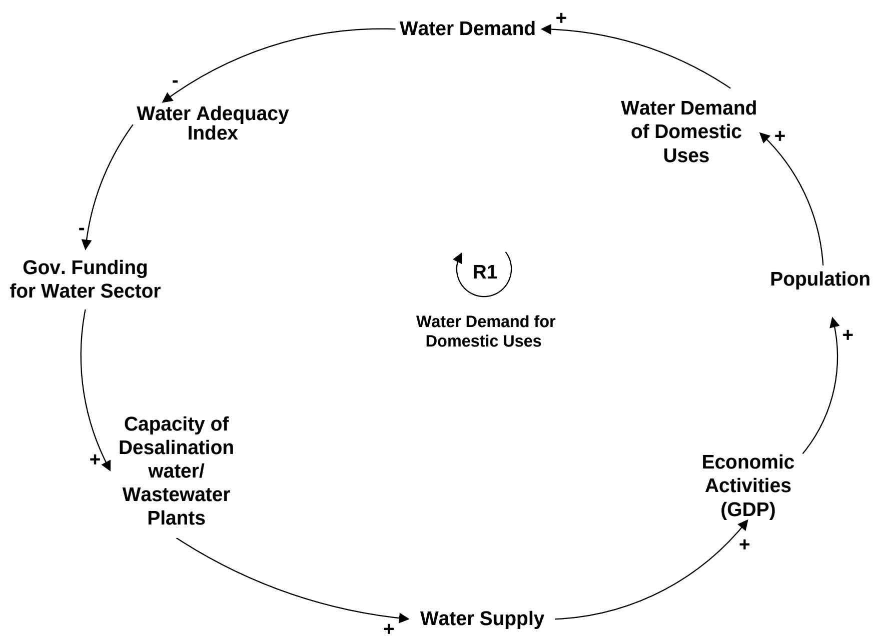


Figure 2 Water demand for domestic uses loop.

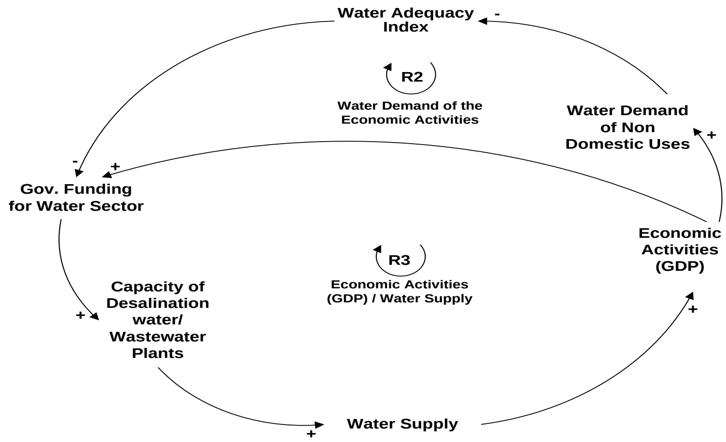


Figure 3 Effect of economic activities (GDP) on water supply loops.

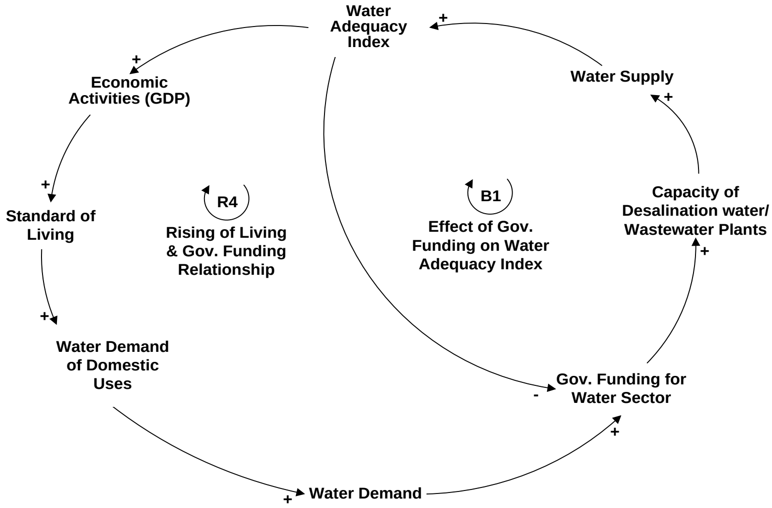


Figure 4 Government funding for water sector loops.

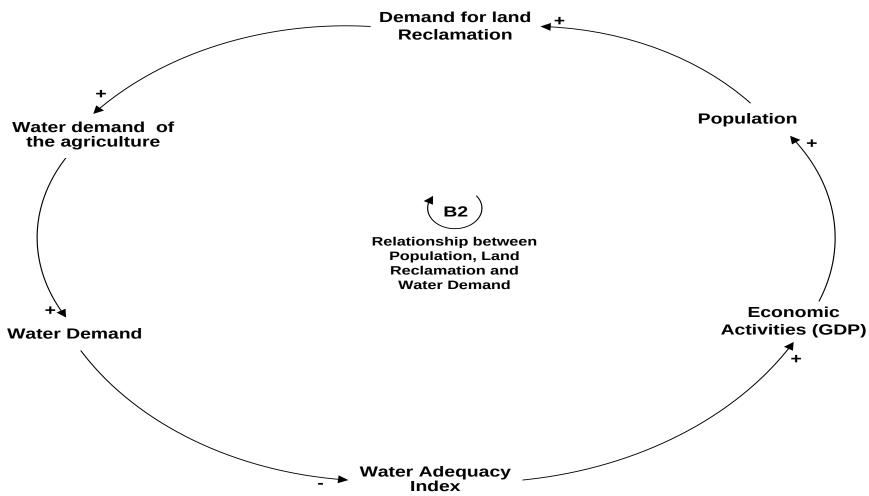


Figure 5 The relationship between Population, land reclamation and water demand loop.

3.5 Stock and flow diagram

Developing the stock and flow diagram are required for the simulation model. The initial step is to identify the causal loop variables as stocks or flows. The following step is to derive mathematical functions that relate each variable to each other. The results of the stock and flow are then coded into the computer using the "Powersim" software package. The needed input data is consolidated and inputted into the simulation model. Appendix B presents the stock and flow diagram of the model.

4. Simulation model Results

4.1 Data input to the model

The model is constructed to interpret and simulate water demand, supply, and uses in Egypt. Table 1 displays the model variables, and their initial values. The model is run from the year 2004 to 2035. These data are real measured data from national/ international organizations.

Table 1 The initial data input to the model

No.	Variable	Units	Value
1	Nile water	Billion m^3	55.5
2	Under Ground Water	Billion m^3	6.1
3	Rainfall	Billion m^3	1.17
4	Drainage water	Billion m^3	4.8
5	Waste water treatment	Billion m^3	1
6	Sea water desalination	Billion m^3	0.067
7	Industry water demand	Billion m^3	1.1
8	Agriculture water demand	Billion m^3	64.13
9	Domestic water Demand	Billion m^3	5.6
10	Water Evaporation	Billion m^3	0
11	Mean Temperature	°C	22.4
12	Population	Thousand Person	68,648
13	Standard of Living	$	1216.11
14	Reclaimed Lands	Thousand Feddan	23.5
15	Economic Activities (GDP)	Billon $	78.85
16	Gov. funding for water sector	Billion L.E	1.1
17	Capacity of waste water plants	1000 m^3/day	15000
18	Domestic uses	Billion m^3	—
19	Agricultural uses	Billion m^3	—
20	Industrial uses	Billion m^3	—
21	Water Supply	Billion m^3	—
22	Water Demand	Billion m^3	—
23	Water adequacy index	Percentage	—
24	Water withdrawal	Billion m^3	—
25	Water Surplus	Billion m^3	—
26	Water shortage	Billion m^3	—

4.2 Outputs

The model outcomes are presented in (Figures 6-11) and the data cover 32 years from 2004 to 2035. The results showed that Egypt's population would increase from about 69 million in the year 2004 to 160 million in the year 2035 as shown in Figure 6. This increase leads to rising domestic water demand per year from about 5.6 billion m^3 in the year 2004 reaching 18.9 billion m^3 in the year 2035 as indicated in Figure 7. The increase in population requires increasing agricultural land, establishing new factories, and expanding services and therefore increasing demand for water. This expectation can be confirmed by loops revealed in Figures (2, 5). Also, this increase in population leads to increasing total water demand from about 73.1 billion m^3 in the year 2004 to 93.84 billion m^3in the year 2035 as shown in Figure 7.

Figure 7 shows that the agriculture sector represents the largest share (82 %) of water demand in Egypt between the different sectors. Figure 8 represents water resources in Egypt. This Figure indicates that all water resources seem-fixed except for agricultural drainage water that expected to increase from about 4.8 billion m^3 in the year 2004 to 23.68 billion m^3 in the year 2035. This means that officials should find unconventional ways to increase the amount of water available. From analyzing the results of water demand and water supply, the authors found that there is a water shortage, thus inadequacy in water as indicated in Figures 9, 10.

As shown in Figure 11, the water withdrawal (uses) incremental over time. This increase results from the rapidly growing population, the agricultural extension uses as well as industrial development and a rise in the standard of living. The effects of this increase can be confirmed by loops clarified in Figures (2, 4).

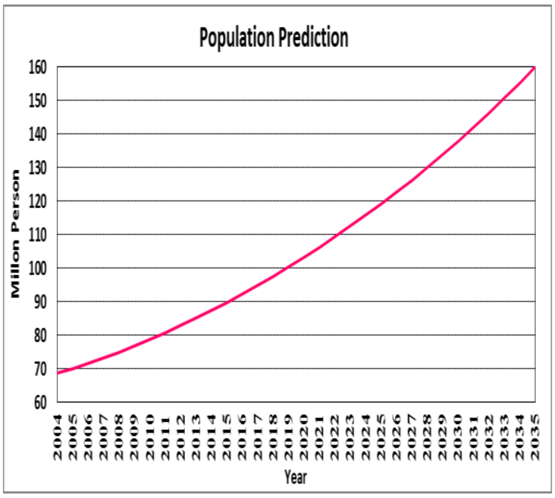


Figure 6 Egypt's population

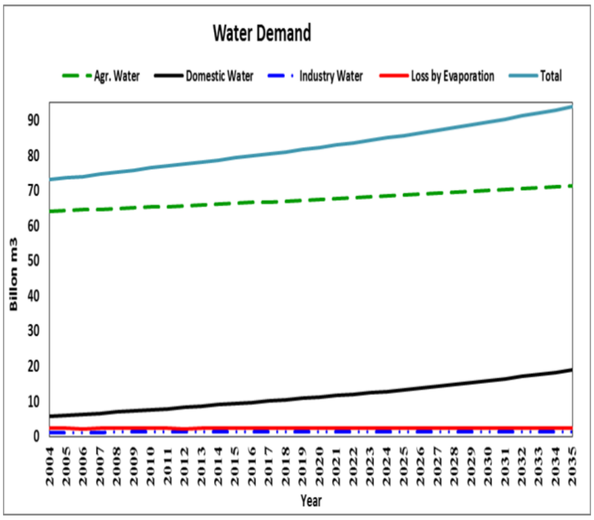


Figure 7 Water demand

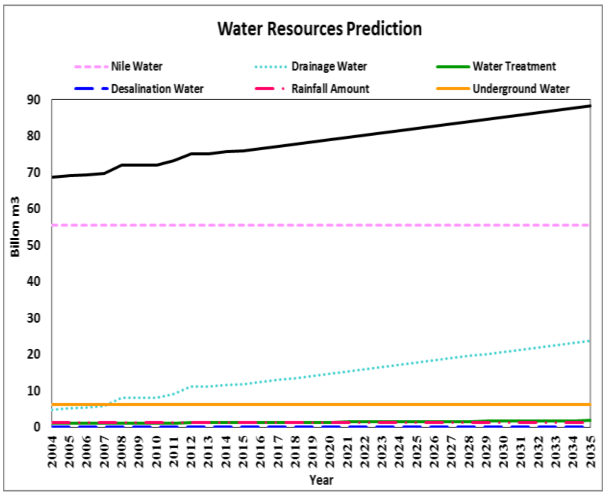


Figure 8 Water resources

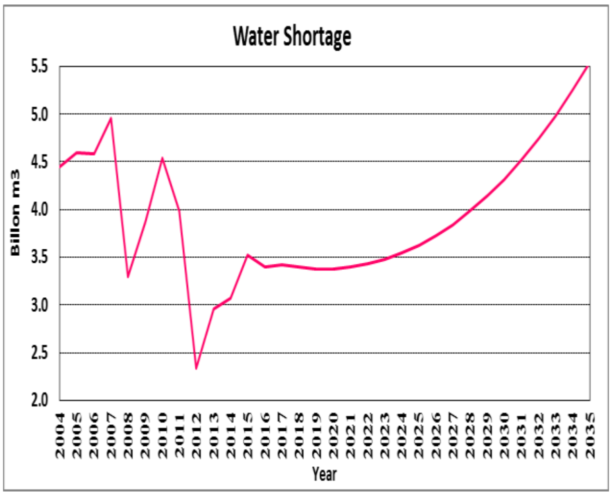


Figure 9 Water shortage

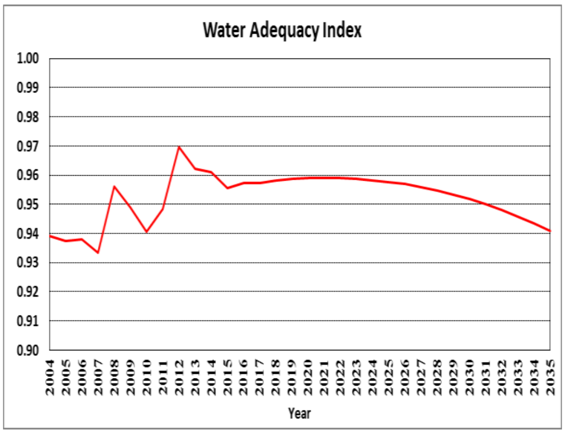


Figure 10 Water Adequacy Index

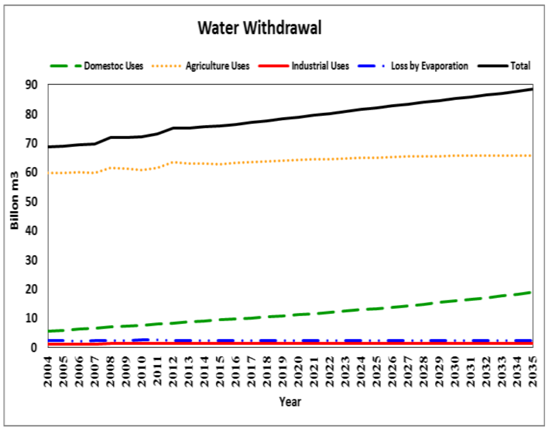


Figure 11 Water withdrawal (Uses)

5. Model validation

To increase the confidence of water resources management in Egypt SD model, the authors executed model calibration and direct structural tests and gathered experts' opinion. Model calibration is "the process of estimating the model parameters (structure) to obtain a match between observed and simulated structures and behavior" (Olava, 2003). Direct structural tests assess the validity of the model structure, by directly comparing the simulated reference mode with knowledge about the real system (Barlas, 1996). In addition, the most frequent techniques in generating and evaluating policies in models of dynamic systems are exploratory scenarios (what-if scenarios) and exhaustive testing by experts. (De Salles et al., 2016).

By comparing the prediction of Egypt's population resulting from the model in the year 2017 with the census of Egypt in the same year (CAPMAS, 2017, p. 1), the authors found that the model estimation is 94,849 million person and the census is 94,798. This means that the population estimated of the model and that of the census are approximately the same. Also, the GDP forecast of the model in the year 2016 is 336.4 billion $, where the GDP according to world bank in the same year is 332.8 (The World Bank Group, 2018). In addition, according to (Zaghloul et al., 2012) Egypt's water needs in the year 2025 is 86.18 billion m^3, while in the model is 85.6 billion m^3 with a change in the result equals 0.7 %. Also, water resources in Egypt in the year 2015 was 76.4 billion m^3 (CAPMAS, The year 2017, P. 173), while in the model is 75.74 billion $m^3$with a change in the result equals 0.86 %. Besides calibration, direct structure test is useful in increasing the dependability of the model. In a real system, the population increases with the rate of 2.3% per year from 2004 to 2015, where the model prediction is 2.5% (Approximately the same). Finally, to ensure the validity of the model, the authors viewed the results of the model to an expert in water and confirmed the validity of the results and the likelihood of occurrence in the future if there are no emergency circumstances in the coming period.

6. Conclusion

A system dynamics model for sustainable water resources management in Egypt containing a causal loop diagram and a stock-and-flow diagram has been developed. This model enables decision makers to the optimal allocation of limited water resources and analyzes the long-term impacts of various investment plans. The researchers use the system dynamics as an approach to analyze and understand the cause and effect of all water resources significant variables and their relationships. It illustrates the concept of water resources through equations and simulation output charts and shows the internal feedback between variables.

The information generated from investigating the outcome of basic runs is valuable to determine the amount of water supply from different sources and water demand for different sectors in the future. Also, this information will enable the decision makers to put the best policies to make water balance between supply and demand and achieve substantial utilization of available water resources. The basic runs reveal the fact that population growth and agricultural needs were the most influential causes of water crisis (shortage) in Egypt and there is an inadequacy in water. Also, they show that the recycling of agricultural drainage water can help in decreasing the gap between water needs and water supply.

Finally, the researchers suggest to put into place the following policies to overcome this shortage:

1. Improving irrigation and draining systems.
2. Using cropping patterns and minimize the cultivated area with high water consuming crops especially rice, bananas, and sugarcane.
3. Changing farm irrigation systems.

4. Development of short-lived plants
5. Upgrade water infrastructure.
6. Increase awareness about water challenge between all stakeholders and enable them to participate in water policy decisions
7. Achieving the concept of virtual water in a precise way.

Acknowledgment

The authors would like to thank Assoc. Prof. Sherein Zahran, the director of Climate Changes department, The Environment and Climate Research Institute, NWRC for her valuable guidance and Dr. Mohammed A. El-Shirbeny the Assoc. Prof. of Irrigation Water Management, Agricultural applications Department, NARSS.

List of abbreviations

Abbreviation	Explanation
SD	System Dynamic
CLD	Causal Loop Diagram
WD	Water Demand
MWRI	Ministry of Water Resources and Irrigation
NWRC	National Water Research Center
CAPMAS	Central agency for public mobilization and statistics
NARSS	National authority for remote sensing and Space Sciences

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Appendix

Appendix A

The main equations of the model are the following:

Eq. (A.1): Population Stock

INIT Population = 69997.

Flow Population = +dt* Population Rate.

Population Rate = Fractional Population Rate * Population.

Fractional Population Rate = Normal Fractional Pop Rate * Effect of GDP on Population.

Eq. (A.2): Domestic Water Demand

Domestic Water Demand (WD) = Normal Domestic WD * Effect of Population on Domestic WD * Elasticity of Standard Of Living on Domestic WD.

Eq. (A.3): Agriculture Water Demand

Agriculture Water Demand = Normal Agriculture WD * Effect of Reclaimed Lands on Agriculture WD.

Eq. (A.4): Industry Water Demand

Industry Water Demand = Normal Industry WD * Effect of GDP on Industry WD.

Eq. (A.5): Water Supply

Water Supply = Nile Water + Drainage Water + Underground Water + Rainfall Amount + Water Treatment + Desalination Water.

Eq. (A.6): Water Demand

Water Demand = Agriculture WD + Domestic WD + Industry WD + Water Evaporation.

Eq. (A.7): Water Adequacy Index

Water Adequacy Index = $\frac{\text{Water Supply}}{\text{Water demand}}$.

Eq. (A.8): Water withdrawal

Water withdrawal (Uses) = Agricultural Uses + Domestic Uses + Industrial Uses + Loss by Evaporation.

Eq. (A.9): Water Surplus

Water Surplus = Water supply – Water withdrawal.

Eq. (A.10): Water shortage

Water shortage (deficits) = Water demand – Water Supply.

Appendix B

The following figures show the stock and flow diagrams of the model (Figures B.1- B.6).

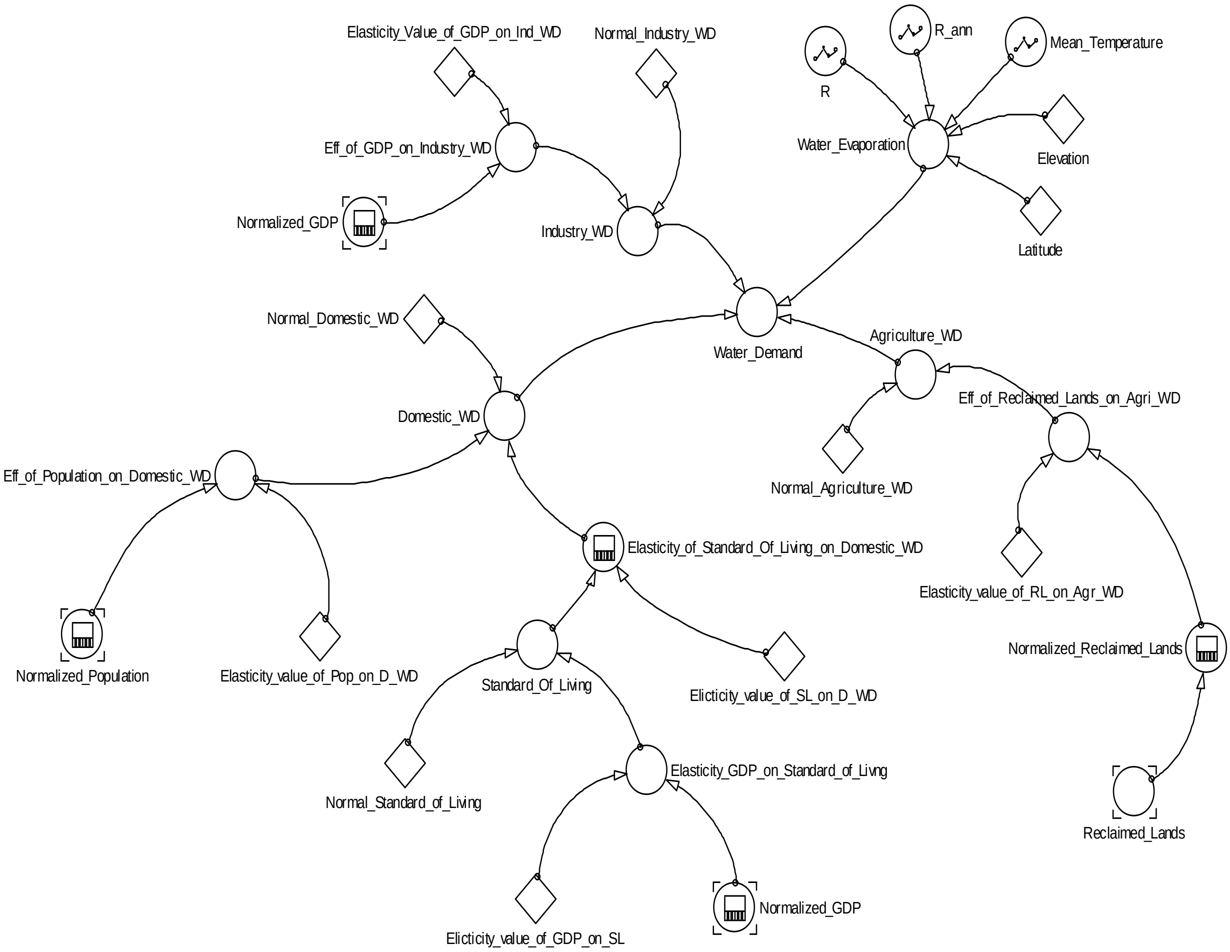

Figure B.1 Water Demand

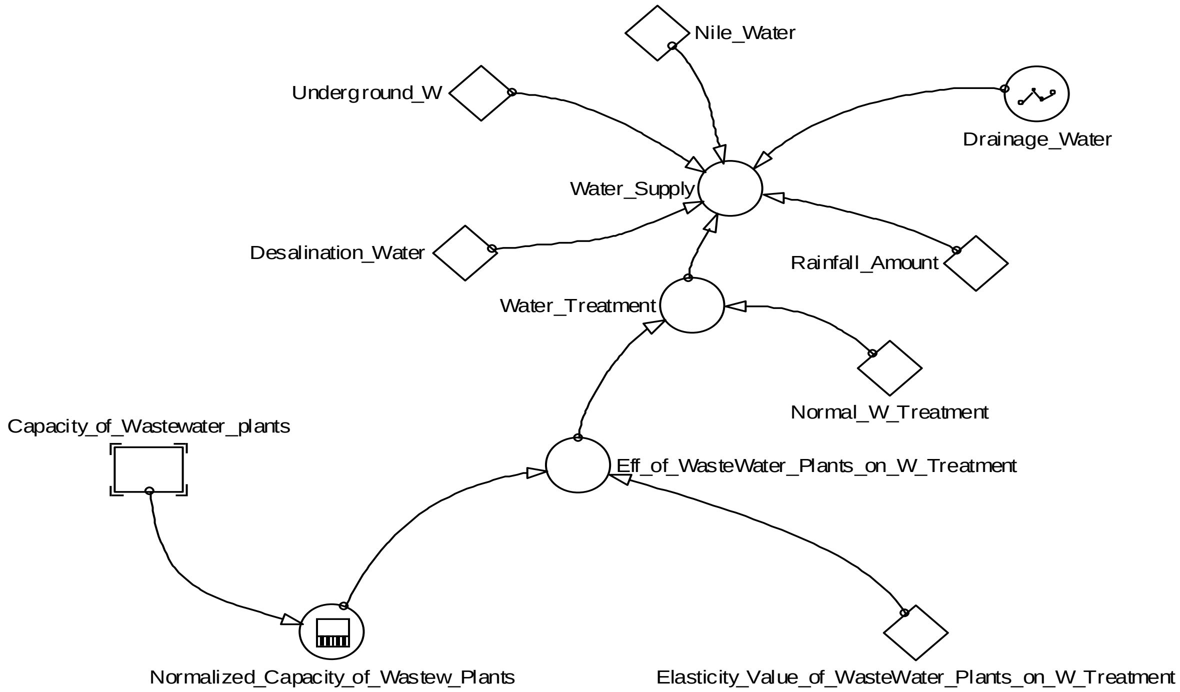

Figure B.2 Water supply

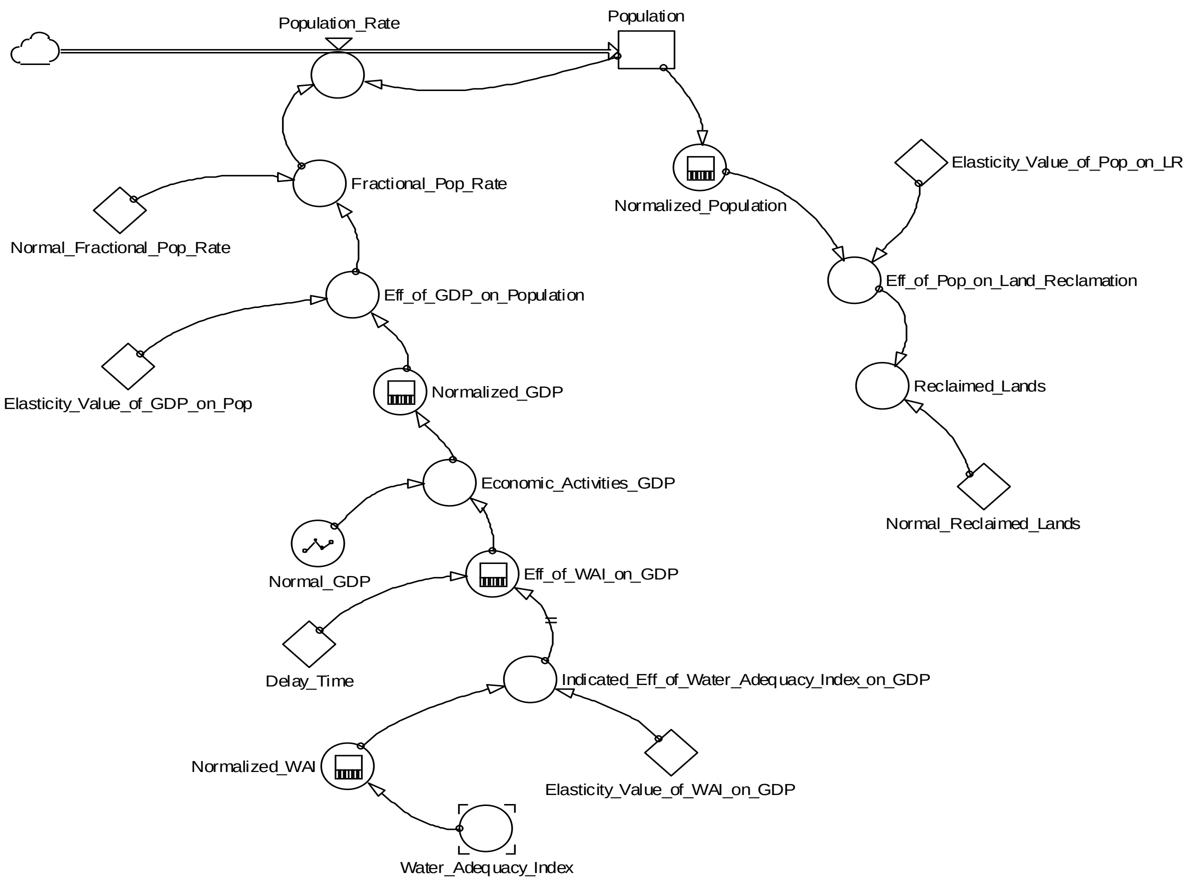

Figure B.3 Population

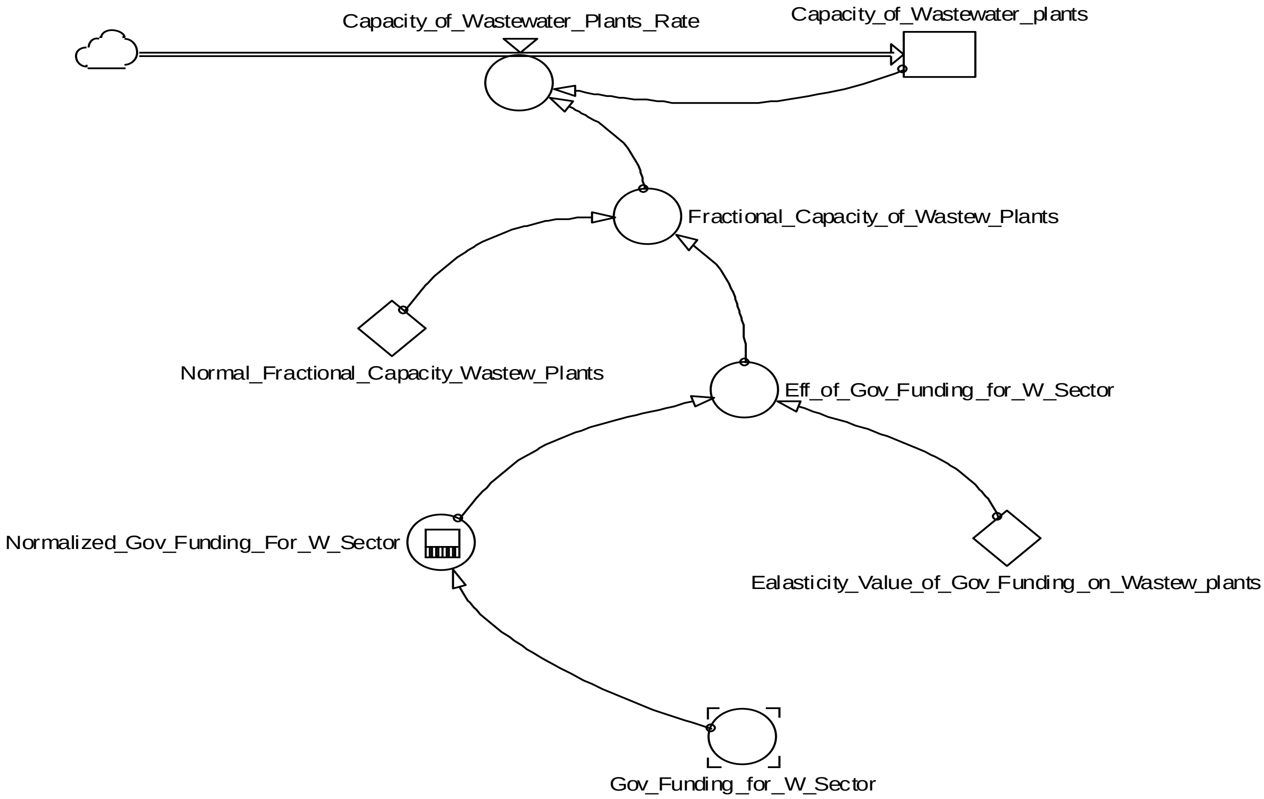

Figure B.4 The capacity of wastewater plants

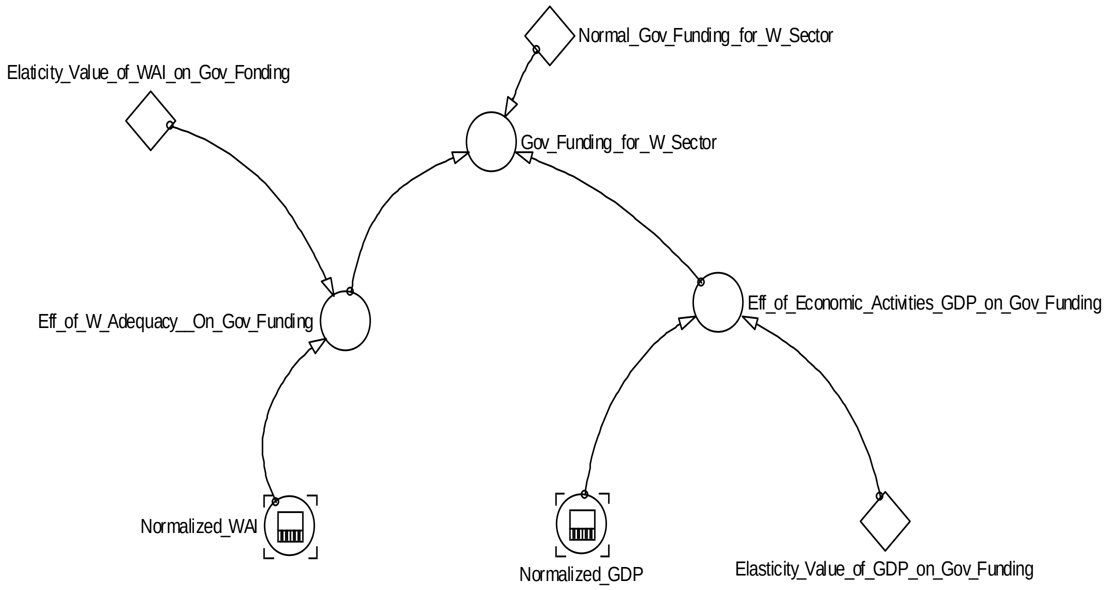

Figure B.5 Government funding for the water sector

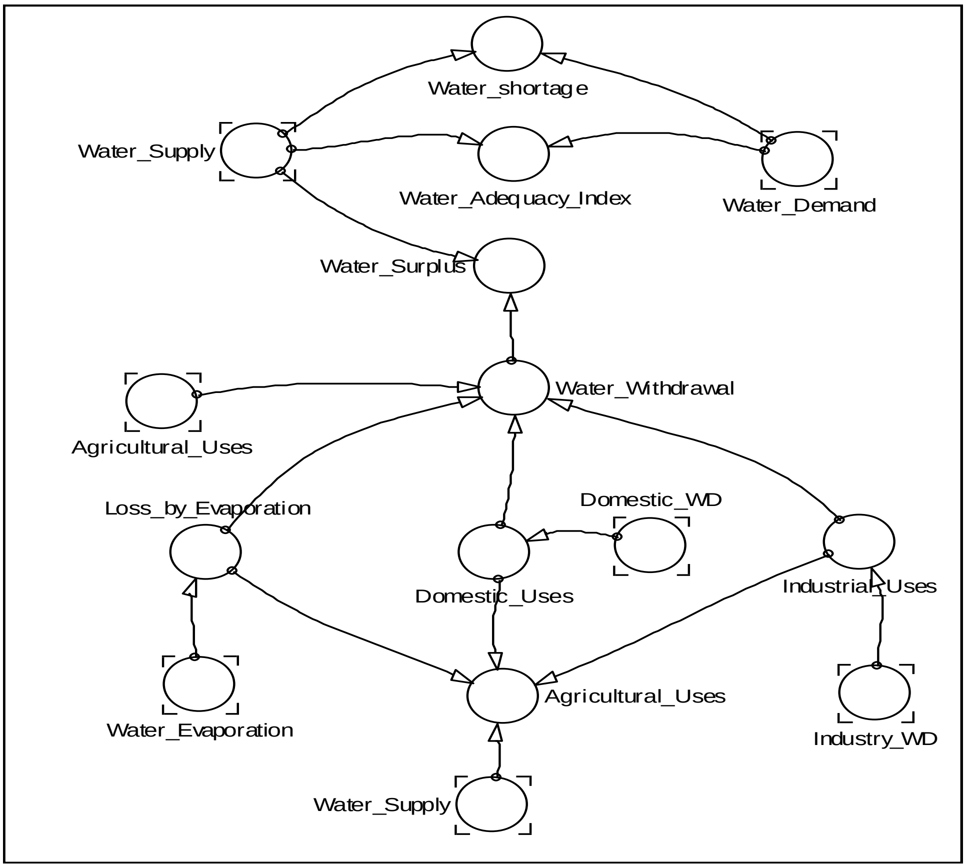

Figure B.6 Outputs of water resources management in Egypt model

The Literature Review of De Novo Programming Technique

Naglaa Ragaa Saeid (1), Hany Gamal EL − Din (2)

Abstract

Most operations research methodology concentrates on the redesign and improved function of existing systems. Very little methodology and efforts are devoted to the design of systems De Novo. Using De Novo programming, several approaches for examining planning problems are described where the objective is not simply to optimize a given system, but to design an optimal system. De novo programming, a system design approach which links system flexibility, efficiency, and optimal system design. It is show that within multi-objective decision making framework, de novo programming may allow the decision maker to achieve an ideal or meta-optimal system performance, or improve the performance of compromise solutions, through the modification or shaping of the feasible region of decision alternatives. This paper represents a brief review over De Novo programming, Literature Review provides a brief insight about the De Novo programming and its applications.

Keywords: Optimization- De Novo Programming – Operations Research Techniques Redesign Systems

1. Introduction

Taha (2010) defined the science of Operations Research (OR) is a quantitative approach to decision making, it's both an art and a science, the art of modeling
the problem and the science of solving the model using (precise) mathematical algorithms. The notion of optimality and the process of optimization are pivotal to the areas of economics, engineering, as well as management and business, etc. Zeleny (1986) introduced a new way of resolving multiple-criteria decision making problems called the De Novo programming to pursue the requirements of modern production which characterized by no-waste, no-buffer, just-in-time operations, full utilization of scarce resources, multiple objectives (quality, worker satisfaction, profits, etc.), and continuous flexibility of design and redesign of systems. Zeleny (1990) explained the purpose of optimizing the system cannot be just to improve the performance of a given, pre-configured system but rather to find the best system configuration itself, i.e., design an optimal system.

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Many Researches like Optimal Design rarely dealt with system design, its configuration or re-configuration. Rather, they focused on valuation of a given system, searching for decision or design variables that maximize a single or multiple measurement criteria or objectives. This review will discuss a theory and methodology of optimal system design embodied in De Novo programming and its applications. This paper is organized as follows: Section (2) introduces the De Novo programming, the general model of the De Novo programming, the formulation of its iterations, and the optimum-path ratios in De Novo programming as alternatives for selecting the optimal system designs to solve De Novo programming problems. Section (3) represents a brief review over De Novo programming providing a brief insight about the De Novo programming and its applications. Section (4) represents the analysis & summary of literature review including the applications used, the methods and techniques applied, and the types of applications on the De Novo programming in categories with percentage. Section (5) discusses the conclusion, the main points of this paper, and its applications.

2. The De Novo Programming

Chen (2008) explained the utilization of De Novo programming to build an efficient planning model of resource allocation. De Novo programming was proposed by Zeleny to redesign or reshape given systems to achieve an aspiration/desired level. The original idea was that productive resources should not be engaged individually and separately because resources are not independent.

When we usually confront a situation that is almost impossible to get optimize all criteria in the real world. We should be to do alternative of all the criteria, this property is so called *trade-offs*. It is a *trade-offs* concept for limitation resource of firm operations level. The scholar Zeleny (2005) suggested trade-offs are properties of inadequately designed system and thus can be eliminated through designing better, preferably optimal system. So, De Novo programming can deal with a multiple criteria optimization problem. We except to build a planning model based on De Novo programming for resource allocation.

Zeleny (2010) represented the general model of De Novo programming by denoting the available amounts of resources $\boldsymbol{b_i, i = 1, \dots, m}$ and their prices $\boldsymbol{p_i}$, then $\boldsymbol{p_1 b_1 + \cdots + p_m b_m}$ represents the total valuation of resources. The individual $\boldsymbol{b_i}$'s are not "given" constants but rather decision variables affecting the value of the objective functions involved. Suppose that $\boldsymbol{B}$ indicates the amount of money available (budget) for the purchases of the resources. We want to maximize profits $\boldsymbol{C}$ for single or multiple objective problems, and the representation of the resource allocation *economic problem* can be formulated in the following LP model:

$$\textbf{Maximize } \boldsymbol{Z = CX}$$

$$\textbf{s.t. } \boldsymbol{AX - b \leq 0\ ,\ pb \leq B\ , X \geq 0} \qquad (1)$$

Where $C \in R^{q*n}$ and $A \in R^{m*n}$ are matrices of dimensions $q \times n$ and $m \times n$ respectively, and $b \in R^{m}$ is m-dimensional unknown resource vector, $X \in R^{n}$ is n-dimensional vector of decision variables, $p \in R^{m}$ is the vector of the unit prices of m resources, and $\boldsymbol{B}$ is the given total available budget.

Solving problem (1) means finding the optimal allocation of B so that the corresponding resource portfolio $\boldsymbol{b}$ maximizes simultaneously the values $Z = CX$ of the product mix $\boldsymbol{x}$. Obviously, we can transform problem (1) into:

$$\textbf{Maximize } \boldsymbol{Z = CX}$$

$$\textbf{s.t. } \boldsymbol{VX \leq B\ , X \geq 0} \qquad (2)$$

Where $Z = (z_1, \ldots, z_q) \in \mathrm{R}^{q}$ and $V = (v_1, \ldots, v_n) = pA \in \mathrm{R}^{n}$.

Let $\boldsymbol{z_{k*}} = max\ \boldsymbol{z_k}$, $\boldsymbol{k = 1, \ldots, q}$, be the optimal value for $\mathbf{k^{th}}$ objective of Problem (2) subject to $VX \leq B, X \geq 0$.

Let $z^* = (z_{1*}, \ldots, z_{q*})$ be the q-objective value for the ideal system with respect to $\boldsymbol{B}$. Then, a *meta-optimum problem* can be constructed as follows:

$$\textbf{Minimize } \boldsymbol{B = Vx}$$

$$\textbf{s.t. } \boldsymbol{Cx \geq Z^*\ , X \geq 0} \qquad (3)$$

Solving problem (3) yields x^*, B^* (= Vx^*) and b^* (= Ax^*). The value $\mathbf{b}^*$ identifies the minimum budget to achieve $\mathbf{Z}^*$ through $\mathbf{x}^*$ and $\mathbf{b}^*$. At $B^* \leq B$, the optimal design reached. Since $B^* \geq B$, the optimum-path ratio for achieving the ideal performance $\mathbf{Z}^*$ for a given budget level $\boldsymbol{B}$ is defined as:

$$\boldsymbol{r^* = \frac{B}{B^*}}$$

And establish the optimal system design as **(x, b, Z)**, where $x = r^* x^*$, $b = r^* b^*$ and $Z = r^* Z^*$. The optimum-path ratio $\boldsymbol{r^*}$ provides an effective and fast tool for efficient optimal redesign of large-scale linear systems.

2.1 The optimum-path ratios in De Novo programming

Shi (1995) summarized In this section, based on the basic optimum-path ratio $\boldsymbol{r^*}$, several optimum-path ratios as alternatives for selecting the optimal system designs to solve De Novo programming problems.

Given a De Novo problem (1), we transform it into problem (2), which is a "knapsack" linear program with q criteria. Let $C = \left(c_j^k\right)_{q*n}$ be the criteria coefficient matrix, where c_j^k is the coefficient for the $\mathrm{j^{th}}$ variable on the $\mathrm{k^{th}}$ criterion. Without loss of generality, we assume $c_j^k > 0$, $\mathrm{v_j} > 0$ and $B > 0$.

Consider the $\mathrm{k^{th}}$ criterion of problem (2) subject to $Vx \leq B$, $x \geq 0$, which is a linear knapsack program. Let $\frac{c_a^k}{V_a} = max_{1\leq j\leq n}\left\{\frac{c_j^k}{V_j}\right\}$ Then, the optimal solution is $x_j^k = \frac{B}{V_a}$, if $j = a$;0, if $j \neq a$. Using x_j^k , we have $b_j^k = Ax_j^k$, and $B_j^k = Vx_j^k$, $k = 1, \ldots, q$. Note that b_j^k is the budget level of production x_j^k with respect to the $\mathrm{k^{th}}$ criterion. The design $\left(x_j^k, b_j^k, z_k^*\right)$ is an optimal system design for a De Novo programming problem with a single criterion. Applying it to problem (1), some optimum-path ratios can be constructed for identifying various optimal system designs.

Given a problem (1), assume $q \leq n$ (i.e., the number of criteria is less than or equal to the number of variables under consideration). Suppose we individually solve k single criterion De Novo programs and obtain solutions $\left(x_{j1}^1, x_{j2}^2, \ldots, x_{jq}^q\right)$.

Without loss of generality, suppose $\left(j_1 \leq j_2 \leq \cdots \leq j_q\right)$. Then, we define $x^{**} = \left(x_{j1}^1, x_{j2}^2, \ldots, x_{jq}^q, 0, 0, \ldots, 0\right)$ as a *synthetic optimal solution* from the solutions $\left(x_{j1}^1, x_{j2}^2, \ldots, \text{and } x_{jq}^q\right)$. Thus, we can obtain $b^{**} = Ax^{**}$, $Z^{**} = Cx^{**}$ and $B^{**} = Vx^{**}$. To utilize (x^{**}, b^{**}, Z^{**}) the design in our study, using problem (3), the relationships between the budgets $B^{**}, B^*, B,$ and b_j^k are summarized in the following theorem that serves as the basis of the optimum-path study.

$$\boldsymbol{B^{**} \geq B^* \geq B \geq b_j^k}\text{ , for } \boldsymbol{k = 1, \ldots, q}$$

Since $\sum \gamma_k = 1$, and $0 \leq \gamma_k \leq 1$, this simply follows from $B \geq b_j^k$, for $k = 1, \ldots, q$ in the Theorem. By the above Theorem, we can define six types of optimum-path ratios as follows:

(i) $r^1 = \frac{B^*}{B^{**}}$; (ii) $r^2 = \frac{B}{B^{**}}$; (iii) $r^3 = \frac{\sum \gamma_k b_{jk}^k}{B^{**}}$

(iv) $r^4 = \frac{B}{B^*}$; (v) $r^5 = \frac{\sum \gamma_k b_{jk}^k}{B^*}$; (vi) $r^6 = \frac{\sum \gamma_k b_{jk}^k}{B}$

In the above optimum-path ratios, $r^4 = r^*$, which is the basic optimum path ratio studied by Zeleny. The ratio r^1 is the optimum-path ratio for achieving the synthetic-optimum performance Z^{**} related to a given meta-optimum budget level B^*; r^2 is the optimum-path ratio for achieving the synthetic-optimum performance Z^{**} related to a given initial budget level B ; r^3 is the optimum-path ratio for achieving the synthetic-optimum performance Z^{**} related to a given combined budget level $\sum \gamma_k b_j^k$; and r^5 is the optimum-path ratio for achieving the ideal performance Z^* related to a given combined budget level $\sum \gamma_k b_j^k$; and r^6 is the optimum-path ratio for achieving the optimum performance Z^c related to a given combined budget level $\sum \gamma_k b_j^k$. Assume the given initial budget level B in problem (1) or (2) can be replaced by either B^* or $\sim\sum \gamma_k b_j^k$. By using these optimum-path ratios, the following optimal system designs can be established:

(i) $x^1 = r^1 x^{**}$, $b^1 = r^1 b^{**}$, and $Z^1 = r^1 Z^{**}$
(ii) $x^2 = r^2 x^{**}$, $b^2 = r^2 b^{**}$, and $Z^2 = r^2 Z^{**}$
(iii) $x^3 = r^3 x^{**}$, $b^3 = r^3 b^{**}$, and $Z^3 = r^3 Z^{**}$
(iv) $x^4 = r^4 x^{**}$, $b^4 = r^4 b^{**}$, and $Z^4 = r^4 Z^{**}$
(v) $x^5 = r^5 x^{**}$, $b^5 = r^5 b^{**}$, and $Z^5 = r^5 Z^{**}$
(vi) $x^6 = r^6 x^{**}$, $b^6 = r^6 b^{**}$, and $Z^6 = r^6 Z^{\text{nd}}$

The meaning of the above optimal system design$\left(x^{\text{i}}, b^{\text{i}}, Z^{\text{i}}\right)$, $i = 1, \ldots, 6$, is that b^{i} , the optimum portfolio of resources to be acquired at the current market prices, p, allows one to produce x^{i} and realize the multicriteria performance Z^{i}. When problem (1) or (2) is actually applied to solve real world problems, these designs may be presented to the decision maker as candidates for the final optimal system design.

3. A review over De Novo Programming

De Novo Programming for the various optimization problems is presented in this section. At the end of this section, the Analysis & Summary of Literature Review is reached for future works including the fields of each problem and its applications.

Zeleny (1986) introduced a new way of resolving multiple-criteria decision making problems (De Novo programming) to pursue the requirements of modern production which characterized by no-waste, no-buffer, just-in-time operations, full utilization of scarce resources, multiple objectives (quality, worker satisfaction, profits, etc.), and continuous flexibility of design and redesign of systems. Bare and Mendosa (1988) introduced the subject of soft optimization using De Novo programming formulation of single and multiple objective LP optimization techniques which incorporate multiple objectives for increasing the utility of forest planning models. Bare illustrate the potential use of designing optimal forest systems in the face of conflictive objectives. A multiple objective LP model is used to illustrate this approach. Both the generation and evaluation of compromise solution under De Novo conditions are discussed.

Zeleny (1990) explained the purpose of optimizing the system cannot be just to improve the performance of a given, pre-configured system but rather to find the best system configuration itself, i.e., design an optimal system. Zeleny presented a theory and methodology of optimal system design embodied in De Novo programming. Li and Lee (1993) presented an improved approach to solve the general multiple criteria De Novo programming where both the goals and the coefficients are treated simultaneously. Depending on the numerical approach, the resulting problems can be solved either as a linear problem combined with a search routine or as a nonlinear programming problem.

Shi (1994) proposes several optimum-path ratios for enforcing different budget levels of resources so as to find alternative optimal system designs for solving multi-criteria De Novo programming problems. Then, the study of optimum-path ratios is applied to solve an optimal pattern matching problem which is formulated by the De Novo programming with a given initial budget level and an optimal pattern preferred by the decision maker. An interactive algorithm is developed to continuously reshape the problem for matching the optimal pattern. A numerical example is also used to illustrate the algorithm.

Babic and Pavic (1996) presented the possibilities for optimal production plan designing by the application of the De Novo programming approach. Production plan for a real production system is defined taking into account financial constraints and given objective functions. The study illustrated how it is possible to design an optimal production program and to provide its optimal functioning and maintenance. Shi (1999) tried to apply multi-criteria De Novo programming to formulate and solve problems of system design that involve multiple decision makers and a possible debt. In the framework of the system design model, each involved decision maker has his or her own preference for the budget availability level associated with multi-criteria under consideration. If the possible debt occurs in the design time, the model allows flexibility for decision makers to borrow additional money from the bank with a fixed interest rate so as to keep the production process feasible. Zeleny (2000) introduced the two fundamental dimensions to management: what is your system and how do you operate it. One can of course operate a bad system very well or a very good system rather poorly. The main foundation of the competitive advantage already recognized and often achieved, is to operate very good systems very well. Managing the optimally designed, high-productivity, tradeoffs-free systems would undoubtedly return the lost joy, pride and self-confidence into modern business and management. He summarized the basic formalism of De Novo programming, as it applies to linear systems.

Zeleny (2005) draw attention to the impossibility of optimization when crucial variables are given and present eight basic concepts of optimality. He chosen a more realistic problem of linear programming where constraints are not "given" but flexible and to be optimized and objective functions are multiple: De novo programming. Huang *et al.* (2005) proposed an optimal resource portfolio by using the De Novo perspective. A numerical example demonstrated the criteria of strategic alliances. The authors explained the formation of strategic alliances and provided solutions for resource allocation in achieving the desired level. In this situation, the De Novo approach is more suitable than traditional mathematical programming. The most critical problem with the De Novo approach is that the required budget will exceed the subject budget using De Novo programming in some situations. But the alliances can overcome this difficulty. They illustrated that the De Novo perspective provides another view on strategic alliances and gives the optimal resource allocation. Unlike traditional mathematical programming, the De Novo approach does not have the limitation of element independence.

Chen and Hsieh (2006) introduced the De-Novo programming problems by extending to a fuzzy dynamic programming problem. First, a traditional De-Novo programming problem is modified to a De-Novo programming problem with multiple fuzzy goals, fuzzy constraints and multiple stages. Second, he regarded this fuzzy multi-stage De-Novo programming problem as a fuzzy dynamic programming problem, which is identical to a fuzzy multi-objective combinatorial optimization problem.

Babic *et al. (*2006) presented the use of multi-criteria approach in designing the optimal production system. They combined the multiple criteria and De Novo programming in a production model. Moreover, it will be applied in a real production system which produces various ferroalloys using a number of different raw materials. The most favorable solutions in conditions of "variable" constraints will be looked for, benefiting De Novo approach. Lastly, the paper will demonstrate how the usual multi-criteria problems could be handled in a different concept of optimization with De Novo programming approach.

Hung *et al.* (2006) identified the optimal maintenance strategies for a pavement management system (PMS) which is a set of tools or methods that assist decision makers in searching optimal resource allocation and then deciding optimal maintenance strategies for keeping pavements in a serviceable condition over a given period of time. The optimal maintenance strategies was identified by three objectives – maximizing pavement improvement, minimizing the incremental cost during maintenance activities, and maximizing pavement serviceability using De Novo Programming to reallocate maintenance resources and obtain the actual optimal resource allocation model for pavement maintenance sections in Taiwan Area National Freeway Bureau (TANFB) and Taiwan Area National Freeway Bureau (TANFB) based on real data. According to the findings, the direction of resources adjustment and improvement strategies are proposed as well.

Chen *et al.* (2008) introduced a combined De Novo programming with Multiple objective decision making (MODM) techniques to solve resource allocation problems for Environment-watershed resource management (EWRM). They discussed a multi-objective model designed from the De Novo perspective to help environmental-watershed optimize their maintenance resource portfolio, and solve the land used resource problem. The new optimization method, a trade-off-free system, can achieve the ideal value of each objective without adding any budget. They designed an optimal systems rather than simply optimizing the given system for the environment-watershed land used resource management.

Chen *et al.* (2008) explored integrating information technology into instruction to build an education resources allocation planning model using De Novo programming for study. They expected building an efficient planning model of integrating information technology into instruction for school education resources allocation using De Novo programming for achieving aspired/desired level base on education resources allocation of school. They made the system in the set budget for accomplishing the resources allocation with minimum cost. They discovered that school can build a model of optimal education resources allocation planning model with De Novo programming. The efficiency planning model using De Novo programming not only can get the optimal resources allocation but also enhance the performance of teaching activities.

Chen *et al.* (2009) used the De Novo programming approach as a strategic alliance alternative to achieve optimal resource allocation in supply chain systems. He developed an efficient resource planning model for best optimal resource allocation results in an enterprise resource portfolio. The resources in the model optimized the trade-offs with the De Novo programming approach.

Zeleny (2010) in the handbook of multi-criteria analysis explored some topics beyond traditional MCDM. He explained the simplest possible terms what multi-objective optimization is, and defined the subject matter, and discussed the role of tradeoffs-based versus tradeoffs-free thinking.

Fiala (2011) presented approaches for solving the multi objective De novo linear programming (MODNLP) problem, extensions of the problem, examples, and applications.

Fiala (2012) used the De Novo programming as a methodology of optimal system design by reshaping the feasible sets in linear systems. He summarized the basic concepts of the De Novo optimization, and presented extensions, methodological and actual applications. He formulated the supply chain problem, and solved it using the De Novo programming approach.

Kasprzyk *et al.* (2012) demonstrated a new interactive framework for sensitivity-informed de Novo planning to confront the deep uncertainty within water management problems. The framework couples global sensitivity analysis using Sobol variance decomposition with multi-objective evolutionary algorithms (MOEAs) to generate planning alternatives. They explored these issues within the context of a risk-based water supply management problem, where a city seeks the most efficient use of a water market. The study examined a single city’s water supply in the Lower Rio Grande Valley (LRGV) in Texas, using 6 objectives problem formulations that have increasing decision complexity for both a 10 years planning horizon and an extreme single-year drought scenario. The de Novo planning framework illustrated how to adaptively improve the value and robustness of the problem formulations. Hung *et al.* (2013) used multi-objectives goal programming to solving priority with the pavement maintenance works in the pavement management system. The De Novo Method used to approach the ideal point. They tried to use this method to solve Taiwan Freeway's maintenance work programming. The analytical results completed by De Novo programming, the performance improved by budget. So de novo programming apply to pavement maintenance can give a new way to solve the problem.

Chakraborty and Bhattacharya (2013) presented a new approach of applying De-Novo programming technique for optimal design of a system. The applicability of the method has been illustrated through examples. It is believed that the solution procedure presented here could be implemented in the solution of other derivatives and extension of De-Novo programming. The advantage of the proposed approach is that it requires less number of variables (only slack variables) to be introduced in the solution procedure and thus reducing the processing time in comparison with the existing method.

Umarusman (2013) suggested De Novo Programming and Min-max Goal Programming approaches and used positive and negative ideals. He explained the Problem-solving phases of the model through illustrative examples. He said that De Novo Programming does not have its unique general solution algorithm. Especially when multi-objective problems are discussed in the light of De Novo hypothesis, the solving method directs decision maker to different solutions. He identified compromise solutions of De Novo programming problems with the use of min-max approach, compromise programming yield important results in preliminary examination conducted by his study. Especially when relative weights are equally important for both Goal Programming and Compromise Programming, obtained solution yields the same results as Zimmermann's fuzzy approach in terms of distance function model. On the other hand, if relative importance is different, more efficient results can be achieved.

Umarusman and Türkmen (2013) introduced brief history of De Novo technique, mathematical definitions of Multi-criteria De Novo Programming, and Global Criterion Method is given with their respective principles. They showed a real firm application where the problem and solution parts are shown. They explained budget given for the same level of production is significantly reduced by an improvement in problem constraints. It can be seen that both Global Criterion Method and simple De Novo solutions give the same values. Optimum solution occurs in first two objective functions for both methods, which results to return of the same value in final calculations. They were aiming to continue studying multi criteria De Novo Programming with and without under Global Criterion Method in future. Tezenji *et al.* (2017) proposed a bi-objective integrated model for supplier location-allocation, capacity allocation and supplier selection, and order allocation problems in two level supply chains. There are five goals of the proposed model. In the first step they proposed a single-objective model to minimize the total costs. In the second stage they used De Novo programming to determine the optimal capacity of selected supplier(s). They used NRGA and NSGA-II algorithms to solve the proposed bi-objective mix-integer nonlinear model. At the end, they proposed various test problems to show the performance of the proposed methodology. Bhattacharya and Chakraborty (2018) presented an alternative approach forthe solution of the general multi-objective De Novo Programming Problem under fuzzy environment in one step using Luhandjula's compensatory $\boldsymbol{\mu_\theta}$-operator. Also the solution obtained by the proposed approach represents an efficient solution of the problem considered under the assumption of the uniqueness of the solution. The method has been illustrated by a numerical example. They showed that this methodology requires less processing time in comparison with the existing ones because through the proposed method, the general MODNPP can be solved in one step only. To make the problem more flexible, instead of crisp coefficients, fuzzy, type2 fuzzy coefficients can be considered and solution procedure can be investigated.

Zhuang and Hocine (2018) explored the potential use of the meta-goal programing approach (meta-GP) for solving multi-criteria De Novo programing problems. Methodologically, the objectives of the De Novo programing problem are converted into meta-goals during formulation to arrive at the most satisfactory decision in the multi-objective decision-making context. This approach is shown superior to the conventional 'multi- criteria solution procedure' for the De Novo programing problem, in that it provides decision-makers with more flexibility in expressing their preferences, by merging the original explicit goals as meta-goals. The proposed model is to a decision case in identifying the best plan for the exploitation of wind energy sourcing is provided, illustrating the effectiveness of the proposed novel solution approach.

4. Analysis & Summary of the Literature Review

Table 1 Summary of the Literature Review

No.	Title	Author(s)	Application	Method
1	**optimal system design with multiple criteria: De Novo programming approach**	**Zeleny (1986)**	**Production system.**	**Applying a New concept of optimality, new way of resolving MCDM conflicts, and new conditions for optimal and continuous system improvement.**
2	**A soft optimization approach to forest land management planning.**	**Bare and Mendosa (1988)**	**Forest planning model.**	**They introduced the subject of soft optimization using De Novo programming formulation of single and multiple objective LP optimization techniques.**
3	**Optimizing given systems vs. designing optimal systems: The**	**Zeleny (1990)**	**Numerical example.**	**A theory and methodology of optimal system design embodied in De Novo**

No.	Title	Author(s)	Application	Method
	De Novo programming approach.			programming.
4	De Novo programming with fuzzy coefficients and multiple fuzzy goals.	Li and Lee (1993)	Numerical approach.	They solved the general multiple criteria De Novo programming problem where both the goals and the coefficients are treated simultaneously.
5	Studies on optimum-path ratios in multi criteria De Novo programming problems.	Shi (1994)	Numerical example.	He proposed several optimum-path ratios for enforcing different budget levels of resources so as to find alternative optimal system designs for solving multi-criteria De Novo programming problems.
6	Multicriterial production planning by De Novo programming approach	Babic and Pavic (1996)	Production program.	Presented the possibilities for optimal production plan designing by the application of the De Novo programming approach.
7	Optimal system design with multiple decision makers and possible debt: A multi criteria de Novo programming approach.	Shi (1999)	Budget availability and possible debt.	He made the framework of the system design model using a multi criteria de Novo programming approach.
8	The elimination of tradeoffs in modern business and economics.	Zeleny (2000)	Production system.	He summarized the basic formalism of De Novo programming, as it applies to linear systems.
9	The evolution of optimality: de novo programming.	Zeleny (2005)	Numerical example.	He drawn attention to the impossibility of optimization when variables are given and present eight basic concepts of optimality including De Novo programming.
10	Motivation and resource-allocation for strategic alliances through the De Novo perspective.	Huang *et al.* (2005)	Strategic alliances (numerical example)	They provided an optimal resource portfolio by using the De Novo perspective in strategic alliances and provided solutions for resource allocation.
11	Fuzzy multi-stage De-Novo programming problem.	Chen and Hsieh (2006)	Fuzzy dynamic programming problem (numerical example)	They extended the traditional De-Novo programming problem to a De-Novo programming problem with multiple fuzzy goals, fuzzy constraints and multiple stages. Then, they regarded this fuzzy multi-stage De-Novo programming problem as a fuzzy dynamic programming problem.
12	Optimal System Design with Multi-	Babic *et al.* (2006)	Production system.	They combined the multiple criteria and De Novo programming in a production model

No.	Title	Author(s)	Application	Method
	criteria Approach.			to design the optimal production system.
13	Optimal resource allocation model for pavement maintenance established by de novo programming method.	Hung *et al.* (2006)	Pavement maintenance in Taiwan Area National Freeway Bureau and Taiwan Area National Freeway.	They identified the optimal maintenance strategies for a pavement management system using the De Novo Programming to reallocate maintenance resources and obtain the actual optimal resource allocation model.
14	Fuzzy Multiple Criteria Decision Making Approach for Environment Watershed.	Chen *et al.* (2008)	Watershed resource management maintenance.	They introduced a combined De Novo programming with Multiple objective decision making (MODM) techniques to solve resource allocation problems for Environment-watershed resource management (EWRM).
15	Build an education resources allocation planning model of school with integrating Information Technology.	Chen *et al.* (2008)	An education resources allocation of school.	They built an education resources allocation planning model using De Novo programming for school by integrating information technology into instruction to achieve the aspired/desired level.
16	Perspective strategic alliances and resource allocation in supply chain systems through the De Novo programming approach.	Chen *et al.* (2009)	Taiwanese IC-design service firms.	They used the De Novo programming approach as a strategic alliance alternative to achieve optimal resource allocation in supply chain systems. He developed an efficient resource planning model for best optimal resource allocation.
17	Multi objective optimization, systems design and de novo programming.	Zeleny (2010)	Numerical example.	He explained the simplest possible terms what multi objective optimization is, defined the subject matter, and discussed the role of tradeoffs-based versus tradeoffs-free thinking using De Novo programming.
18	Multi objective De Novo Linear Programming.	Fiala (2011)	Illustrative example.	He presented approaches for solving the multi objective De novo linear programming (MODNLP) problem, extensions of the problem, examples, and applications.
19	Design of Optimal Linear Systems by Multiple Objectives.	Fiala (2012)	Numerical example.	He used De Novo programming as a methodology of optimal system design by reshaping the feasible set in linear systems. He formulated the supply chain problem, and solved it using De Novo programming approach.
20	Many-objective de	Kasprzyk *et*	Single city	They demonstrated a new interactive

No.	Title	Author(s)	Application	Method
	Novo water supply portfolio planning under deep uncertainty.	***al.* (2012)**	**water supply in the Lower Rio Grande Valley (LRGV) in Texas.**	**framework for sensitivity-informed de Novo planning to confront the deep uncertainty within water management problems by coupling global sensitivity analysis using Sobol' variance decomposition with multi-objective evolutionary algorithms (MOEAs).**
21	**Apply De Novo Programming in Pavement Maintenance Strategy Optimization.**	**Hung *et al.* (2013)**	**Taiwan Freeway's maintenance work system.**	**They used multi-objectives goal programming to solve priority with the pavement maintenance works in the pavement management system using the De Novo method to approach the ideal point.**
22	**Optimal System Design under Multi-Objective Decision making using De-Novo Concept: A New Approach.**	**Chakraborty and Bhattacharya (2013)**	**Numerical example.**	**Presented a new approach of applying De-Novo programming technique for optimal design of a system. The advantage of the proposed approach is that it requires less number of variables, thus reducing the processing time.**
23	**Min-Max Goal Programming Approach For Solving Multi-Objective De Novo Programming Problems.**	**Umarusman (2013)**	**Numerical example.**	**He suggested De Novo Programming and Min-max Goal Programming approaches using positive and negative ideals. He identified compromise solutions using min-max approach, compromise programming yield important results.**
24	**Building Optimum Production Settings using De Novo Programming with Global Criterion Method.**	**Umarusman and Türkmen (2013)**	**A production system that produces four types of plastic balls**	**Global Criterion Method was given with their respective principles using De Novo programming. It was seen that both Global Criterion Method and De Novo solutions give the same values.**
25	**Bi-objective location-allocation-inventory-network design in a two-echelon supply chain using de novo programming, NSGA-II and NRGA.**	**Tezenji *et al.* (2017)**	**Bi-objective location allocation inventory network.**	**They proposed In the first stage a single-objective model to minimize the total costs. In the second stage they used De Novo programming to determine the optimal capacity of selected supplier(s). They used NRGA and NSGA-II algorithms to solve the proposed bi-objective mix-integer nonlinear model.**
26	**Solution of the general multi-objective De-Novo programming problem using compensatory operator under fuzzy environment.**	**Bhattacharya and Chakraborty (2018)**	**Numerical example.**	**They presented an alternative approach for the solution of the general multi-objective De Novo Programming Problem under fuzzy environment in one step using Luhandjula's compensatory μ_θ–operator to solve the general multi-objective De Novo Programming Problem.**
27	**Meta goal programing approach for solving multi-criteria de Novo**	**Zhuang and Hocine (2018)**	**Install (build) wind (energy) farm (sites)**	**They explored the potential use of the meta-goal programing approach (meta-GP) for solving multi-criteria De Novo**

No.	Title	Author(s)	Application	Method
	programing problem.		for the Algerian government.	programing problems. Methodologically, the objectives of the De Novo programing problem are converted into meta-goals during formulation, to arrive at the most satisfactory decision in the multi-objective decision-making context.

Table 2 The number citations according to the Journal or sources

No.	Source	Citations
1	Engineering costs and production economics	1
2	International journal of general systems	1
3	Canadian journal of forest research	1
4	Journal of mathematical analysis and applications	1
5	Pergamon	1
6	International Journal of Operations Research	2
7	New Frontiers of Decision Making for the Information Technology Era	1
8	International Conference on Evolutionary Multi-Criterion Optimization	1
9	ELSEVIER	5
10	Global Business@ Economics Anthology	1
11	Joint international conference on computing and decision making in civil and building engineering	1
12	Advanced Materials Research	1
13	Industrial Engineering and Engineering Management	1
14	International Journal of Sustainable Strategic Management	1
15	Handbook of Multicriteria Analysis, ed: Springer	1
16	Acta Universitatis Palackianae Olomucensis. Facultas Rerum Naturalium. Mathematica	1
17	Multiple Criteria Decision Making/University of Economics in Katowice	1
18	Environmental Modelling & Software	1
19	International Journal of Computer Applications	1
20	International Journal of Logistics Systems and Management	1
21	Journal of Physics: Conference Series	1
Total number of citations		27

From the Analysis of the Literature Review, the De Novo programming is a good field for building the optimal system design. Figure 1 represents the applications on the De Novo programming technique, it has been shown that (DNP) applications used as follows:

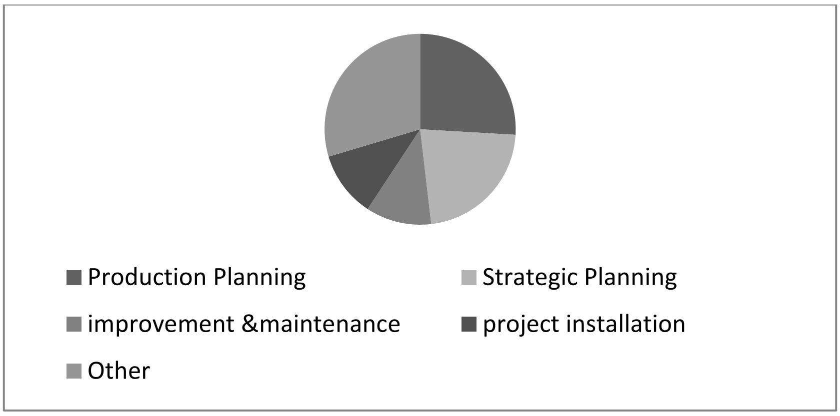

Figure 1 The percentage of applications of De Novo Programming on different areas

26% of the applications used in production planning to find the optimum resource portfolio for different type of products (Plastic balls, wood utilization, ferroalloys, clothes, hardware, software, and health care), 22% used in Strategic planning (strategic alliances, funding, supply chains, and inventory design), 11% used in improvement & maintenance (pavement maintenance, Freeway's maintenance, and watershed resource maintenance), 11% used in project installation (installing wind energy farm, water supply portfolio, and building an education system), and 30% on other type of applications

The De Novo programming approach made a new evolution for the concept of optimality. This technique is more helpful for the decision maker to allocate the optimum resource portfolio specially while having tradeoffs between the objectives of the multi criteria decision making problems to meet the ideal point of the solution which is frequently outside the feasible set of solution. The most critical problem with the De Novo approach is that the required budget could exceed the subject budget using the De Novo programming, so that the optimum path ratio in some situations is used to avoid the raised level of the required budget related to the available one.

5. Conclusion:

The De Novo programming is a technique which uses to redesign a system reaching to optimal solution. The objective is not simply to optimize a given system, but to design an optimal system. De Novo programming can deal with single or multiple criteria optimization problems. A brief review of De Novo programming is presented in this paper, then Analysis and Summary of the Literature Review. Applications of De Novo programming for various optimization problems also discussed.

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A simulated model of sprinklers irrigation systems

Naglaa Ragaa Saeid Hassan(1) and Ahmed Al Sayed Mohammed Shahin (2)

Abstract

Center pivot irrigation is a form of overhead sprinkler irrigation consisting of several segments of pipe (usually galvanized steel or aluminum) with sprinklers positioned along their length, joined together and supported by trusses, and mounted on wheeled towers. The machine moves in a circular pattern and is fed with water from the pivot point at the center of the circle. The sprinkler flow rate out of each sprinkler orifice is based on the water pressure supplied to the sprinkler inlet. The objective of this paper is to build a simulated model **of center pivot irrigation** to optimize the performance of system by estimating the expected number of a sprinkler and diameter of nozzle.

Keywords: Surface irrigation, Irrigation districts, Water management, Reservoir management

1. Introduction

Water is the main yield-determining factor in the majority of agricultural systems. Irrigation systems help growers manage weather related risks by effectively supplementing rainfall (Perry et al. 2002). To sustain agricultural production in the coming years, it is important to optimize irrigation systems, adjusting water application to crop water requirements. This will help protect both the quantitative and qualitative aspects of water conservation.

Center pivot irrigation is a form of overhead sprinkler irrigation consisting of several segments of pipe (usually galvanized steel or aluminum) with sprinklers positioned along their length, joined together and supported by trusses, and mounted on wheeled towers. The machine moves in a circular pattern and is fed with water from the pivot point at the center of the circle. The system is in use, for example, in parts of the United States, Australia, New Zealand, and Brazil and also in desert areas such as the Sahara and the Middle East. Center pivots are typically less than 1600 feet (500 meters) in length (circle radius) with the most common size being the standard 1/4 mile (400 m) machine. A typical 1/4 mile radius crop circle covers about 125 acres of land. To achieve uniform application, center pivots require an even emitter flow rate across the radius of the machine. Since the outer-most spans (or towers) travel farther in a given time period than the innermost spans, nozzle sizes are smallest at the inner spans and increase with distance from the pivot point.

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Aerial views show fields of circles created by the watery tracings of "quarter- or half-mile of the center-pivot irrigation pipe, created by center pivot irrigators which use "hundreds and sometimes thousands of gallons a minute.

The advantages of center pivot and lateral move systems are:

- **Precise application:** The systems are able to apply a prescribed volume of water to match crop water requirements. It reduces the opportunity for surface runoff or deep percolation if the system is designed to match soil infiltration characteristics.
- **Reduced variability:** The reported application efficiencies for new well designed machines are generally in the 80-95% range, compared to 50-90% for surface irrigation systems.
- **Lower labor requirements:** The labor's requirements are generally lower than surface irrigation but it depends on the system and\ or the degree of automation of the machine.
- **Opportunities for fertigation:** Fertigation allows the targeted application of small quantities of nutrients, with a reasonable uniformity of application and less risk of nutrient losses. The irrigation system may also be used to apply herbicides and pesticides.
- **Less land forming:** The system can work on rolling topography. However, there might be a need for some land forming for surface drainage or rainfall induced runoff. The sprinkler flow rate out of each sprinkler orifice is based on the water Pressure supplied to the sprinkler inlet. See (Fig 1 : 4)

Fig 1 Vertical View For center pivot irrigation

Fig 2 Engineering Drawing of Pivot

Fig 3 Pump and center of pivot

Fig 4 Towers of Pivot & sprinkler

Hager, (2006) define operation research (OR) as the discipline that helps us in decision making which is based upon the information technology. The main objective of OR is to utilize limited resource for more benefits. Simulation models where decision makers want to develop simulators to look for improvement and to test and establish bottom line for the improvement idea that are being made. Simulation models linked to decision support systems for the management of irrigated areas constitute powerful tools to achieve these goals (FAO, 1994; Hall, 1999; Walker, 1999; Playán et al., 2000).

In the last decades, the development of such models has been boosted by developments in computer science and the widespread use of personal computers. Different approaches have been used to simulate the processes characterizing an irrigated area. In this paper, the center pivot simulation model is used to improve the design of new systems and to modify existing systems with the view of improving irrigation performance. The objective of this paper is to build a simulated model **of center pivot irrigation** to optimize the performance of system by estimating the expected number of a sprinkler and diameter of nozzle. This paper is organized as follows: Section 2 presents "**Research Optimization Techniques in Irrigation**". Section 3 considers "**Methodology**" which explains **steps of building the simulation model** and figure about suggested irrigation model. Section 4 introduces "**The details of proposed computerized irrigation simulation model**" which explain the details about the input, processing and output units and finally Section 5 presents "Conclusion and future work".

2. Research Optimization Techniques in Irrigation:

Centre pivot simulation models have been used to improve the design of new systems and to modify existing systems with the view of improving irrigation performance. The simulation of center pivot performance has been the subject of a series of research efforts since the 1960s. Bittinger and Logenbaugh (1962) simulated precipitation under center pivots with the objective of defining the optimal sprinkler spacing in order to obtain uniform water distribution. They developed an analytical model of precipitation under a sprinkler assuming that its water application pattern was either triangular or elliptical. The model was based on the additional hypotheses of continuous movement and linear or circular sprinkler trajectory. They estimated the irrigation depth by moving the water application pattern at the same velocity of sprinkler movement on the pivot lateral. Heermann and Hein (1968) continue this line of research by taking into account the overlapping effect of neighboring sprinklers, and introduced the uniformity coefficient that bears their name. This led to the introduction of the CPED (center pivot evaluation and design) software package (Heermann and Stahl, 2004). CPED input data included sprinkler positions on the lateral, discharge, radial application pattern and time of system revolution. Babel et al. (2005) develop a model for optimal allocation of water to competing demands using two optimization techniques, i.e. weighting technique (WT) and simultaneous compromise constraint (SICCON) technique. The develop model was found capable of allocating water among six sectors with maximizing either satisfaction or net economic return or both.

In other cases, the organizational and social aspects of an irrigated area have been modeled together with the production techniques, in order to model farmers' water use. Applying new technologies to irrigation water management leads to improvements in the productivity and sustainability of agricultural systems. Ines, et al, 2006, conduct an interesting study by combining remote sensing simulation model and GA to discover water management option in irrigated agriculture. Results show that adjusting sowing date and distribution with deficit irrigation, can improve regional yield.

Bagher and Payman, 2009, use GA for optimizing water delivery program. They found that GA is useful for water distribution problem in irrigation channels. Schutze et al, 2009, employed evolutionary optimization technique to find a near optimal solution of the global optimization problem within reasonable computational time. The results so obtained were compared with complex evolution algorithm, optimization algorithm, simulated annealing and differential evolution. The new tool developed shows striking superiority over the existing optimization techniques. Pais, et al, 2010, conduct a study to optimize cost of drip irrigation system using GA. The results show that there in improvement in the calculation runtime and in cost of drip system, as compared to other models available. Tranetal, 2011, develop a model based on dynamic optimization model for managing and optimizing multiple resources for irrigation and fisheries

Mtolera, et al, (2014) develop an algorithm using a particle swarm optimization technique to optimize irrigation tree pipe networks layout and size. A result obtained is compared to the non-optimized method and GA. They observed a quick response from their model with an increase in search space as compared GA. Yoo, et al, (2014) apply Harmony search optimization technique for identifying optimal pipe size in looped irrigation water supply system. The main aim of the research is to develop an algorithm and program to find out the optimal and cost-effective pipe diameter for a looped irrigation system. The algorithm developed can be applied to real life problems and it is more promising than others available models.

3. Methodology "Simulation Model"

Simulation is one of the most widely used operations research and management science techniques, if not the most widely used. A simulation is the imitation of the operation of a real-world process or system over time. Simulation involves the generation of an artificial history of a system and the observation of that artificial history to draw inferences concerning the operating characteristics of the real system. Simulation does not usually provide a recommended decision as does an Optimization model; it provides operating statistics. A primary benefit of simulation analysis is that it enables us to experiment with the model.

3.1 Steps building the Simulation model

- **Problem Definition**

  Optimal rationalization of water resources through the identification location of sprinklers along the irrigation system according to specific factors and inputs such as the amount of water, pressure and land area through the design of a computer system

- **Project Planning**

  Before developing a simulation, we identify what is to be simulated, the degree of simulation fidelity required, and how the resulting data will be used. Many additional details must be addressed as well. There must be a simulation software development process that deals with issues such as determination of the optimal distribution of the location of the sprinklers length pivot through the design of a computer system for that the simulation is to be operated, including the definition of input data sets, and how simulation output data is analyzed and used as input for a sprinklers programming.

- **System Definition**

  After completion of the simulation, the main purpose of the system is to avoid the installation of sprinklers at fault locations along the pivot where the locations of these sprinklers are determined according to specific criteria in the form of mathematical and physical equations.

- **Model Formulation**

  This is the stage in the modeling process where we creates a mathematical equations representation of a conceptual model Is consistent with the problem under study where these equations were formulated in the code of the system in which we have been designed for this purpose.

- **Input Data Collection & Analysis**

  There is no doubt that The main source of data in this field is the agricultural companies where we collected the data from the specialists and were analyzed and indexed by nature and priority use to obtain the required outputs.

- **Model Translation**

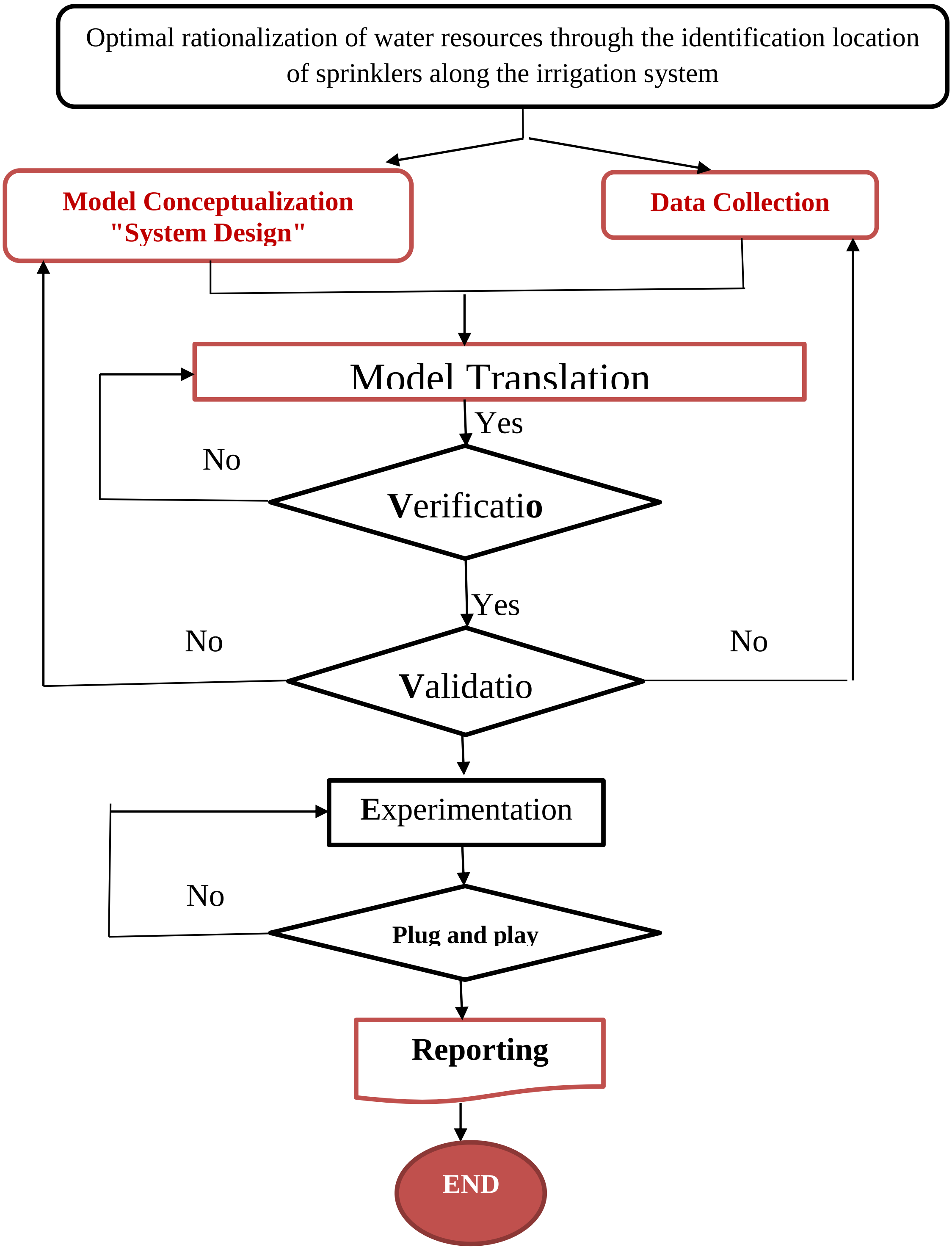
  Both the input and output of the simulator were designed in the input screens and output screens that the user can easily handle during the input and get information from the system.

- **Verification & Validation**

  At this stage, the results and outputs are tested step-by-step to ensure their validity and compliance with the actual outputs of other systems.

- **Experimentation**

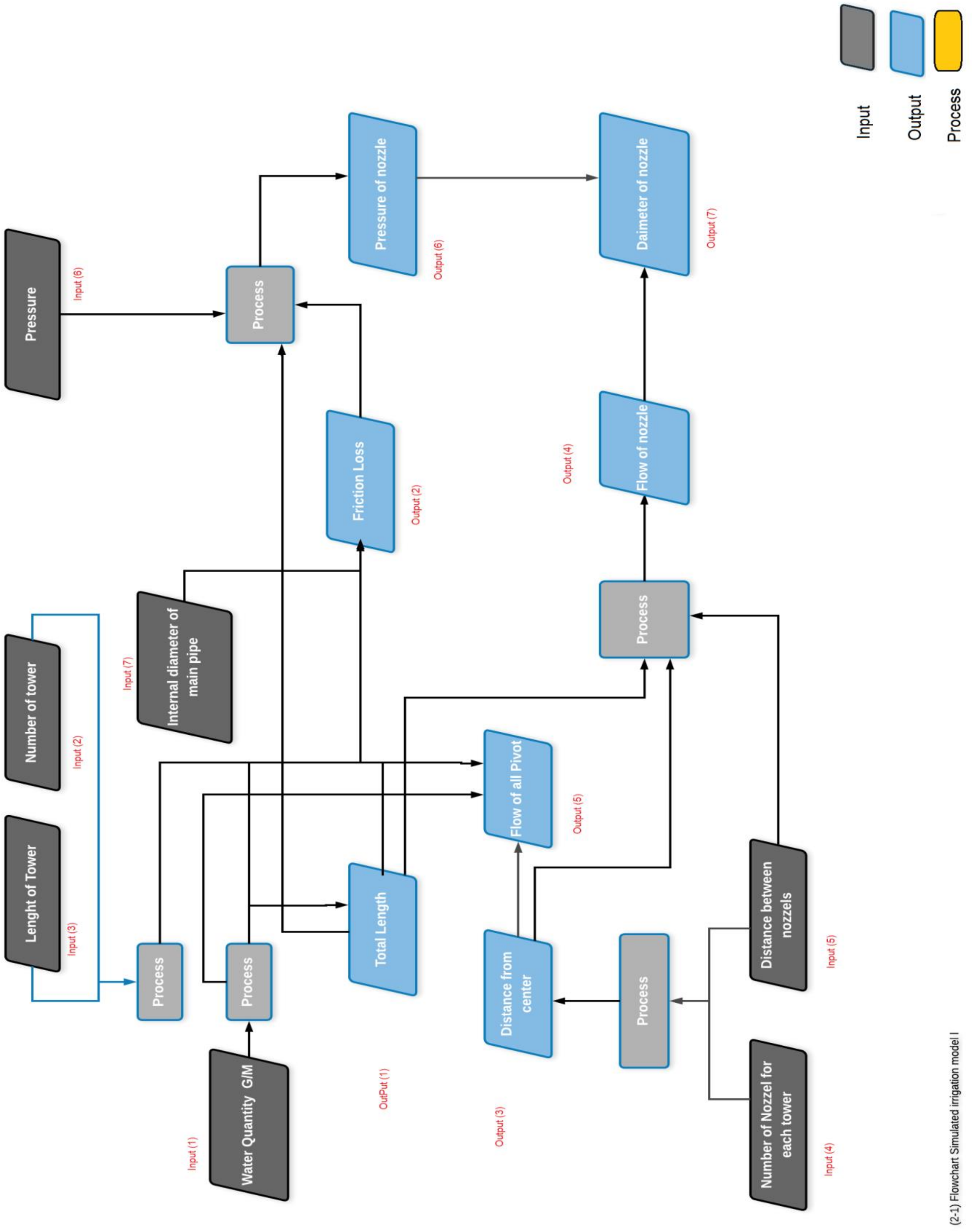
  The outputs were validated and matched with the systems already implemented in some companies. Our system has been implemented in many agricultural companies



Flowchart 1 The suggested Simulated model for system Irrigation

4. The details of proposed computerized irrigation simulation model

- Data flow and processing



Flow chart 2 Details about Simulation irrigation model

Inputs:

- The Quantity of water coming out of the well Gallon/Min.
- The number of towers of pivot.
- Tower length in meters.
- The number of nozzles contained in the tower.
- The distance between all the nozzles.
- Internal Diameter Mm
- Pressure at the ending of the flow of water from the well "Last nozzle".

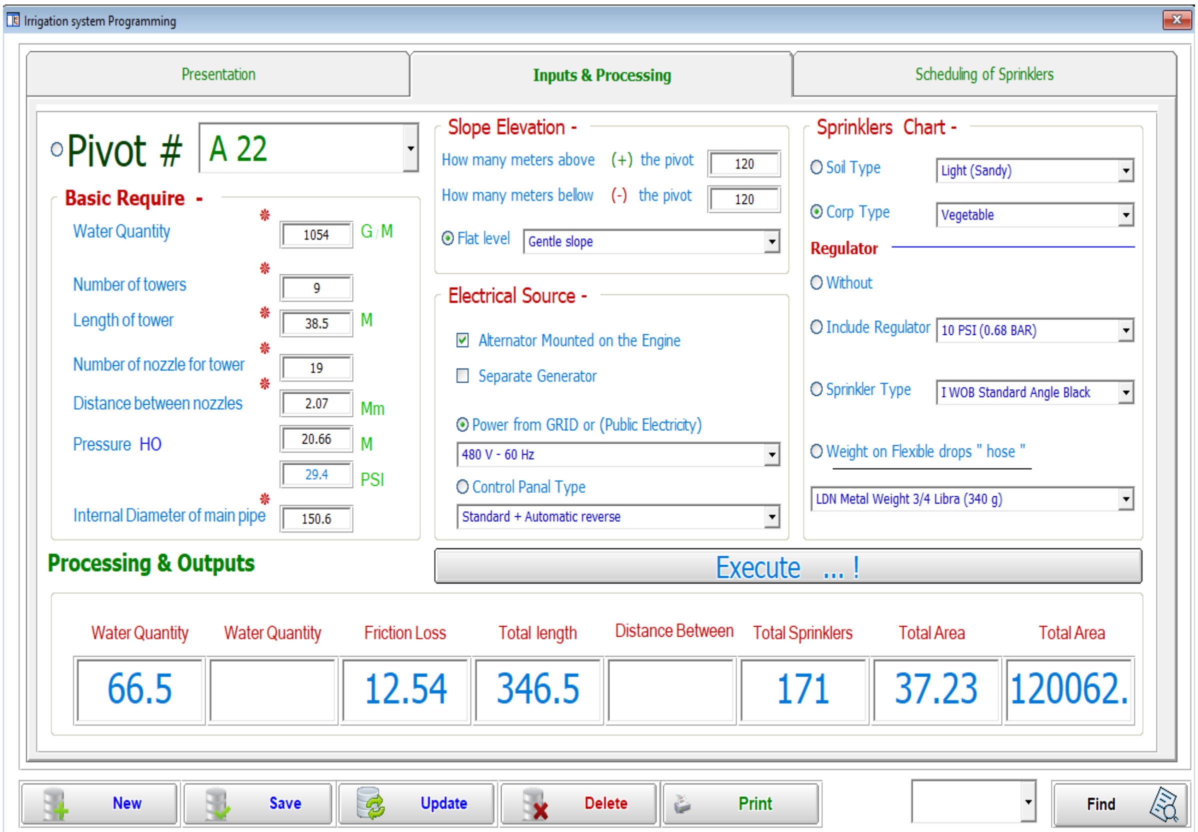


Fig 5 Inputs Screen

In this screen the user enters the data we referred to it before and save it as temporary in memory to go the second step in the system is to process this data to get the information.

Processing:

After the completion of the first step of data entry and temporary storage is called to be processed by inserting them in mathematical and physical equations as we will explain later as a detailed for each one.

Water Quantity: The user can enter the data about the amount of water out from the pump with unit gallon per minute for the system to be converted to another unit, a liter per second to match the mathematical equations carried out by the system, On the other level, it is converted to a gallon unit per minute per hectare to determine the total amount of water per hectare.

Water Quantity L/Sec = Water quantity G/M ÷(15.85)

Water Quantity G/M/Hectare = Water quantity G/M ÷Total Area / Hectare

Friction Loss

This can be calculated by the physics equation

(Hazen-Williams Equation - calculating Head Loss in Water Pipes)

Total towers length

Total length of towers = Number of towers * Length of tower

Total nozzles

Total nozzle = Number of nozzle for tower * Number of towers

Total Distance between nozzles

Total Distance between nozzles **=** Distance between nozzles * Total nozzles

Total Area / Hectare

Total Area / Hectare =

= (((Total length of towers ^ 2) * 3.14) / 10000) - (((38.5 ^ 2) * 3.14) / 10000)

Total area per square meters

Total area per square meters = (Total length of towers ^ 2)

Outputs:

Nozzle #	Distance From Center	Flow Of Nozzle	Flow Of All Pivot	Pressure Of Nozzle	Diameter Of Nozzle
1	2.07	0.005	66.498	33.06	2
2	4.14	0.009	66.491	32.92	2
3	6.21	0.014	66.479	32.78	3
4	8.28	0.019	66.462	32.64	3
5	10.35	0.024	66.441	32.5	4
6	12.42	0.028	66.415	32.35	4
7	14.49	0.033	66.384	32.21	4
8	16.56	0.038	66.348	32.07	5
9	18.63	0.043	66.308	31.93	5
10	20.7	0.047	66.263	31.79	5
11	22.77	0.052	66.213	31.65	5
12	24.84	0.057	66.158	31.51	6
13	26.91	0.062	66.099	31.37	6
14	28.98	0.066	66.035	31.23	6
15	31.05	0.071	65.966	31.1	6
16	33.12	0.076	65.892	30.96	6
17	35.19	0.081	65.814	30.82	7
18	37.26	0.085	65.731	30.68	7
19	39.33	0.09	65.643	30.54	7
20	41.4	0.095	65.551	30.43	7
21	43.47	0.1	65.453	30.29	7
22	45.54	0.104	65.351	30.15	8
23	47.61	0.109	65.245	30.02	8

Fig 6 Outputs screen and scheduling nozzles

The outputs include two kinds of information **(The illustrated figures & the results needed) as follows:**

A) The overall figures such as:

- A Total area of pivot /Hectare.
- A Total number of nozzles to be added to the pivot.
- The Total length of pivot towers.
- Water quantity liter/sec.
- Quantity of water Gallon/Meter /Hectare.

B) As for specifically

- The distance between each one of the nozzles from the center
- The quantity of water flowing from each one of the nozzles
- The Quantity of water flowing to the pivot at the circle
- Water pressure in the mother tube at each one of nozzle
- The last and most important is the size of the nozzles "Diameter nozzles"

Analysis & results:

Column #1 Nozzle number

It is a number generated from an iterative loop that is repeated by the number of nozzles distributed over the total length of the towers.

Column #2 Distance between Nozzles

It is **given** and is determined based on the design of the hub manufacturer.

Column #3 Distance from Center

It is a computation of the distances between the nozzles and the distance from the center.

Column #4 Flow of Nozzle

The flow of nozzle is calculated through the following equations:

(2 * Distance from Center * Distance between Nozzle * Water Quantity) ÷ (Total area per square meters)

Column #5 Flow of All Pivots

It is calculated through the following equation:

(Water Quantity * (1 - (Distance from Center) ^ 2) ÷ (Total area per square meters)

Column #6 Pressure of Nozzle / m

It is calculated through the equations depends on Previous steps.

Column #7 Diameter of Nozzle

The type of nozzle depends on the diameter of nozzles according to their manufacturers

A Real Example:

Table 1 the kinds of diameter of nozzles according to their manufacturers

Nozzle No	**Diameter of Nozzle**
1	**2**
2	**2**
3	**3**
170	**23**
171	**23**

Table 2 The inputs and outputs of real example

#	**Input**	**Data**
1	Water Quantity G/M	1054
2	Number of towers	9
3	Length of tower	38.5
4	Number of nozzle for tower	19
5	Distance between nozzles	2.07
6	Pressure HO	20.66
7	Internal Diameter of mother pipe M/M	150.6
#	**Output**	**Info**
1	Water Quantity L / Sec	66.5
2	Water Quantity G/M/Hec	28.31
3	Friction Loss HF	12.54

So, the Table 2 shows that when the water quantity for example 1054 G/M , the No. of towers = 9 ….and ….so on Then, the water quantity will be 66.5 L/sec.

5. Conclusions and future work

Improper installation of sprinklers in an unsuitable location causes damage to crops and wastewater resources, also the flexibility of the system where we can program different types of tower segments and this is what has been added recently. This paper considers a central pivot simulator model to improve system performance through optimum distribution of sprinklers locations along the pivot.

Future work will be about the central control of the pivot through the control panel connected to the system receives commands to turn on and off the pivot**.**

Acknowledgment

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Queueing System with Priority for Some Customers Case Study: National Bank of Egypt

Faten Mohamed Ali Suliman (1)

Abstract

This study investigates comparative study between performance measures of the queueing system without and with priority with application on the National Bank of Egypt- Zagazig Branch, using daily data for customer access and the rate of service performance during the period of July 2 until August 8 in 2014. This study is used this phenomenon and program of QM for windows. The applied study found that the average length of the class of priority, and also the average service time are less than them in the case of priority by almost half.

Keywords: Queueing System, service performance, Priority service

1. Introduction

The customers have defined the queue as where they wait before being served. A queue is characterized by the maximum permissible number of customers that it can contain. Queues are called infinite or finite, according to whether this number is infinite or finite. Queueing System are often analyzed by analytical methods or simulation. The later technique is a general of wide applications able to incorporate many complexities of a model, but its main drawback is the potentially high development and computational cost to obtain accurate results [Bejan (2007)].

The use of priority-discipline models often provides a very welcome refinement over the more usual queueing models. Many real queueing systems fit these priority-discipline models much more closely than other available models. Rush jobs are taken ahead of other jobs, and important customers may be given precedence over others. Therefore,

The distinction between the two models is whether the priorities are non - preemptive or preemptive. With non-preemptive priorities**,** a customer being served cannot be ejected back into the queue (preempted) if a higher priority customer enters the queueing system. Therefore, once a server has begun serving a customer, the service must be completed without interruption [Pardo and Fuente (2007)]. With preemptive priorities**,** the lowest-priority customer being served is preempted (ejected back into the queue) whenever a higher-priority customer enters the queueing system. A server is there by freed to begin serving the new arrival immediately.

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The Egyptian Governmental Banks play an important role in the stability of the Egyptian economy. But recently, many leading foreign banks have been established in Egypt. To be able to compete with these leading banks, the Egyptian Governmental Banks have to improve their performance efficiency and to present a high quality service. The customers dealing with some departments' service at Zagazig Branch of National Bank of Egypt suffer and complain from the long times they spend in the bank to acquire specific their needed service. This happens especially in specific days in each month and specific days in each week [Mohamed (2008)]. This paper aims to provide suggestion that may help decreasing the time spent to get served. This paper is organized as follows: Section 2 presents "**Literature review**". Section 3 discusses "**Methodology**". Section 4 introduces the "**Case study and empirical results**". Finally, section 5 presents "**Conclusion**".

2. Literature Review

Sarhangian, (2011) has discussed first study for delay system with different classes of impatient customers. He analyzed the M/G1/1+M queue serving two priority classes under the static non-preemptive priority discipline. He also studied the multi–server priority queue considering two cases depending on the time to abandon distribution begin exponentially distribution or deterministic. In all models, he obtained the Laplace transforms of the virtual waiting time for each class by exploiting the level of crossing methods. He derived the steady-state system performance measure. He considered in the second part of the steady-state waiting time distributions of a two class M/G1/1 queue operating under a dynamic priority discipline. He found an accurate approximation for the steady-state waiting time distribution of low- priority customers and he also obtained bounds for the variance of the waiting time of high- priority customers.

Walraevens et al. (2013) have presented study depth analytical of a semi – preemptive priority scheduling discipline. The discipline eliminates the deficits of both the full and non-preemptive versions under the non-preemptive category. They have used probability generating functions and the supplementary variable techniques. Guesmi & Djemal (2013) have presented a scalable architecture for a high performance IP switch based on Priority Active Queue Management (PAQM), which provides multimedia services with improved quality of service (QOS) in the communication system. A performance analysis of an optimized (PAQM) algorithm is presented using an NS-2 network simulator to evaluate the capacity of the internet protocol (IP) switch to support (QOS). The results show that this system can achieve the maximum through to put with low levels of delay. To achieve high performance, they have implemented the proposed algorithm using 0.35 μ m CMOS technology, the performance of which is subsequently analyzed. Sarhangian & Balcioglu (2013) have studied a first passage time problem for a class of spectrally positive levy processes. By considering the special case where the levy process is a compound Poisson process with negative drift .They obtained the Laplace–Stie1tjes transform of the steady state waiting time distribution of low priority customer in a two–class M/G/1 queue operating under a dynamic non- preemptive priority discipline.

Iftikhar et al. (2014) have focused to analyze a three queues priority model for low power Wireless Body Area Network (WBAN), which enables to provide guaranteed quality of service (QOS) parameters such as queue, queueing, through put and packet loss rate . They also simulate the behavior of traffic in (WBAN) to further evaluate the proposed analytical framework.

3. Methodology

One can specify many stochastic processes taking place in the described queueing systems. Some of the characteristics of these stochastic processes are of special interest and may well serve as system performance characteristics.

Let us begin with the notions of busy period and idle period (or vacation period). The busy period is the period of time during which the server is occupied either with servicing of the request or with the switching. The notion of busy period is intuitively absolutely clear. We shall call the periods of time which alternate busy periods by idle periods. It is clear that a busy period follows some idle periods and vice versa.

Let $\pi = \{ \pi^{(1)} , \pi^{(2)} , \ldots\ldots\}$ be consecutive busy periods of the system. One may consider that busy periods π are independent and identically distributed (i.i.d) random variables with some cumulative distribution function (c.d.f) π (t). The sequence π of consecutive busy periods in priority queueing system under all schemes but the "wait and see" mode of behavior of server is a sequence of (i.i.d) random variables. The busy periods in the system with "wait and see" mode of behavior of the server are independent due to Markovian property of the incoming flows [Bejan, (2007)].

3.1 Single Service M/ M/1 Model

Consider the (M/M/1) where M stands for Markoven, 1 server, the arrival and service rates are λ and μ, respectively. The service discipline is assumed to be first come first served (FCFS). Assuming that steady state, access rate is less than the rate of service (λ<μ). Moreover, if the waiting capacity is infinite, the queueing models assume that inter-arrival and service times are exponentially distributed, then the probability density function for the time between successive arrivals would be [Bastani (2009)]

$$\mathbf{f(t)} = \boldsymbol{\lambda e^{-\lambda t}} \qquad \mathbf{t \geq 0} \ , \boldsymbol{\lambda} > \mathbf{0} \qquad \textbf{(2-1)}$$

Equivalently, the arrivals can be said to follow the Poisson process, a collection $\{ N\,(t)\,, t\ \geq 0 \}$ of random variable. Where N(t) is the number of customers that have occurred up to time (t) , starting from time 0 . The Poisson distribution is given by [Taha. A (2007)]

$$p_r\{N(t)\ \ t \geq 0 = \frac{(\lambda\mu)^n e^{-\lambda t}}{n!} \qquad (2\text{-}2)$$

We now proceed to compute some performance measures. The probability p is given by that the service provider is busy (the rate of use of the system)

$$\mathbf{P} = \frac{\lambda}{\mu} \qquad (2\text{-}3)$$

The possibility of disruption of facilities or service (the probability of the absence of any unit in the system)

$$\rho_0 = 1 - \frac{\lambda}{\mu} \qquad (2\text{-}4)$$

The probability of having one customer in the system

$$\rho_1 = \left(\frac{\lambda}{\mu}\right)^n \ \rho_0 \qquad (2\text{-}5)$$

The probability of the existence of n customers in the system

$$\rho_n = \left(\frac{\lambda}{\mu}\right)^n \ \rho_0 \qquad (2\text{-}6)$$

The average number of customers (service recipients) in the system

$$L_s = \frac{\lambda}{\lambda\mu} \qquad (2\text{-}7)$$

The average number of customers in the queue (the average length of the waiting row)

$$L_q = \frac{\lambda^2}{\mu(\mu-\lambda)} \qquad (2\text{-}8)$$

The average elapsed time for one customer in the system

$$W_s = \frac{1}{\mu-\lambda} \qquad (2\text{-}9)$$

The average elapsed time for one customer in the queue

$$W_q = \frac{1}{\mu(\mu-\lambda)} \qquad (2\text{-}10)$$

3.2 Priority Model

We consider a single server queueing system serving two types of customers; class-1 and class-2, each having its own respective line and the arrival process for both types is state independent. A higher priority is assigned to class-1. Suppose that the service rule within each class is FIFS and the priority system is preemptive resumed, i.e. during the service of low priority customer's service is interrupted and will be resumed again when there is no high priority customers in the system. We denote by the number of the customers of class i (i=1, 2) [Sarhangian (2011)].

Let the number of customers in the first class is restricted to a finite number L including the one being served, if any, and the number of the second class is infinite. Let also λ_1, λ_2 denote the arrival rates for the two classes and let μ_1,μ_2

denote the service rates for two classes respectively. Denote the traffic intensities by $\rho_{1=}{}^{\lambda_1}/_{\mu_1}$, $\rho_{2=}{}^{\lambda_2}/_{\mu_2}$ and the steady state probability that the system is in state (i , j), where i is the number of the high priority customers and j is the number of low priority customers in the system. Clearly, the governing difference equations of the system under consideration are given by [Tarabia (2007)].

$$(\lambda_1+\lambda_2)\rho_{0,0}=\mu_1\rho_{1,0}+\mu_2\rho_{0,1} \qquad (2\text{-}11)$$

$$(\lambda_1+\lambda_2+\mu_2)\rho_{0,j}=\lambda_2\rho_{0,j-1}+\mu_1\rho_{1,j}+\mu_2\rho_{0,j+1} \quad ,j\geq 1 \qquad (2\text{-}12)$$

$$(\lambda_1+\lambda_2+\mu_1)\rho_{i,0}=\lambda_1\rho_{i-1,0}+\mu_1\rho_{i,j-1} \quad 1\leq i\leq L-1 \qquad (2\text{-}13)$$

$$(\lambda_1+\lambda_2+\mu_1)\rho_{i,j}=\lambda_1\rho_{i-1}+\mu_1\rho_{i+1+j}+\lambda_2\rho_{i,j-1}, 1\leq i\leq L-1 \quad ,j\geq 1 \qquad (2\text{-}14)$$

$$(\lambda_2+\mu_1)\rho_{L-0}=\lambda_1\rho_{L-1,0} \qquad (2\text{-}15)$$

$$(\lambda_2+\mu_1)\rho_{L-1}=\lambda_1\rho_{L-1,j} \quad ,j\geq 1 \qquad (2\text{-}16)$$

4. Case study & the empirical results

The comparison between the obtained results concerning the performance measures in the case of without priority and with priority is performed at the National Bank of Egypt Zagazig Branch for the period time from 2 July to 4 August in 2014 as it is given in Table 1.

Table 1 (service Performance Rate without and with Priority from 2 July to 4 August 2014)

		all times				priority		
	average no. of tickets per hour				average no. of tickets per hour			
	arrival rate	service rate	Minutes	No. per hour	arrival rate	service rate	minutes	No. per hour
02-July	65.33	00:02:56	2.93333333	20.4545455	45	00:02:14	2.233333	26.86567
03-July	67.40	00:03:37	3.61666667	16.5898618	51.2	00:02:14	2.233333	26.86567
06--July	83.71	00:05:05	5.08333333	11.8032787	59.43	00:01:37	1.616667	37.1134
07-July	62.83	00:03:09	3.15	19.047619	44.67	00:01:55	1.916667	31.30435
08-July	60.40	00:04:02	4.03333333	14.8760331	43.2	00:02:47	2.783333	21.55689
09-July	64.60	00:03:24	3.4	17.6470588	47.6	00:02:19	2.316667	25.89928
10-July	71.40	00:03:05	3.08333333	19.4594595	55.4	00:02:27	2.45	24.4898
13-July	62.00	00:03:59	3.98333333	15.0627615	45	00:02:27	2.45	24.4898
14-July	60.20	00:03:51	3.85	15.5844156	41	00:02:25	2.416667	24.82759
15-July	40.33	00:03:29	3.48333333	17.2248804	29.17	00:02:21	2.35	25.53191
04 August	57.67	00:05:00	5	12	29	00:03:22	3.366667	17.82178

The analysis of these data yields the following results: in case of queue without priority we obtain: λ= 16.33, μ= 63.26, ρ= 0.25 , while in case of queue with priority we obtain λ= 42.39, μ= 107.26, ρ= 0.39, Let L= 20.

From the previous results, we can reach the following performance measures as it shows in Table 2.

Table 2 (Comparison between Queues without and with Priority)

Performance measure	Without priority	With priority
L_q	2	5
L_s	7	13
W_q	19.8	21.6
W_s	55.2	76.8

From this comparison, its clear that, the average number of customers in the queue (not counting the customer being served at the server's window) increases at a rate of 3 customer service expected performance borne and vice versa in the other way. It is the sum of the average number of customers in the queue plus sum of the average number of customers in the system more than doubled in the event of a priority.

The average wait time in the queue without priority = 19.8 minutes in case of a priority than the waiting time 2 minutes for each customer.

5. Conclusion

- The average number of customers in a queue = 2 and the average number of customers in the system = 7 which indicates that in case of priority, these is wasting time until the client gets the service.
- The average number of customers in a queue without priority = 5 and the number of customers in the system with priority = 13, this means that in the presence of a priority customer bears almost twice as much time to expect in the classroom to get service.
- The client takes around 19.8 minutes waiting to perform service while waiting 21.6 minutes in case of a priority.
- The customers with certain priorities either preemptive or non-preemptive affect negatively on the length of the queue falls to existing customers in the queue.

In order to avoid breakdown points in the performance of the bank. To save the time of the customer, it has to avoid the priority discipline:

1- Addition a property to ATM allows the customer to deposit either for each money or checks.

2- Canceling surcharges when withdrawals from ATMs in agreement with other banks and re-distributed geographically and increase the number of machines.
3- Transferring system must be applied on the account number directly.

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Solving the Problem of Tardiness Vessel Using a Simulated Model

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Abstract

A container terminal is a zone of the port where sea-freight dock on a berth and containers are loaded, unloaded and stored in a buffer area called yard. Nowadays congestion in ports becomes main focus for many researchers to analyze due to its huge importance in international trade and economic growth.

The objective of this paper is to apply simulation analytical methodologies for making the problem more detailed than theoretical algorithm. So, building a simulation model for vessel is to improve its performance especially in tardiness's Vessel by describing and classifying the main logistics processes and operations in container terminals for their optimization. Vessel Simulation model represent a real problem and possible changes that can be modified easily .with small adjustments in the model

Keywords: Vessel Arrivals, port congestion, world trade, Simulation, Container handling problems

1. Introduction

Transportation gateways(seaports, airports, and land border crossings) are the entry and exit points for international merchandise trade between Egypt and countries around the world, transportation gateways play critical roles in Egypt international merchandise trade and economy(Azevedo et al. (2009)).

Egyptian businesses depend on these seaports for facilitating the exchange of .merchandise with trading partners around the world Logistics, which reflects the management of the cargo flow and shipping service from origins to destinations, is one important channel in transportation. Seaports always play a strategic role in the development of domestic and international trade of a country whether it is a developing or developed country; ports play an active role in sustaining the economic growth of a country.

Countries with inefficient seaports have higher handling costs where transportation of goods in containers by sea has been the most important for round the world trade exchange and so port systems must have been nourished in the recent decades (Liao, (2017)) Supporting and financing port development projects nowadays returns with huge impact in economic growth and for some countries, it become their main national income.

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Challenge coping with rapid changes in modern world that have huge intensive changes occurring like some congestions in hub ports and even smaller ports which sometimes blocks the waterway causing huge delays in transit time impacting service time upon vessel arrivals to ports pressing port facilities and shorter time maintenance to strive with the flow without delaying services causing facilities to crash being restless efforts serving vessels.

Congestions drastically increase the costs of freight, consumers /traders, .travel time and reduce freight flow, reliability and predictability (Guan, (2016)) introduces the delay at the port facilities as one of the pressing issues facing the industry. It performs critical functions of pickup and delivery of containers to and from the terminal for shippers which threated the productivity and compromises service level.

The objective of this paper is to build a simulation model for vessel is to improve its performance especially in tardiness's Vessel by describing and classifying the main logistics processes and operations in container terminals for their optimization. Vessel Simulation model represent a real problem and possible changes that can be modified easily with small adjustments in the model.

This paper is organized as follows. Section2 introduces "literature review" about the problem. Section 3 considers **"Problem definition**". Section 4 presents “**The methodology of simulation model**". Section 5 introduces "**The proposed model for solving the real problem"**. Section 6 presents **"the results and recommendations"** and finally Section 7 **"Conclusion"**.

2. Literature review

This section shows the literatures review about the recent published researches. The port industry is under pressure to deal with the ever increasing freight volume.

Port congestion at marine container terminal is considered a major issue facing vessels to berth. Countries with inefficient seaports have higher handling costs where transportation of goods in containers by sea has the most important for round the world trade exchange.

Table1 **Literature review**

Author	Application	Method
Pham (2007)	US Marine Terminals	He Implements and compared four regression techniques to utilize webcam data to predict truck queuing time.
Azevedo et all (2009)	Container Terminals in the Iberian Seaports	They quantified the performance using DEA 'Data Envelopment Analysis' & Data Mining together comparing Operational Data of ports.
Fan (2010)	Europe & Northern America	He developed an optimization model under conditions of congestion and stochastic variables that optimizes network flow.
Wang (2013)	US Port Trailer crossdock	Decreased transportation lead time using dynamic simulation models to compare FCFS, Look-ahead, Min. processing time methods.
Baran & Gorecka (2015)	Singapore, Hongkong, Rotterdam & Hamburg	They used DEA & MPI 'Malmquist Productivity Index' to compare technical efficiency in productivity of container port than technological.
Guan (2016)	California- US	Applied multi server queuing model to analyze terminal gate congestion and quantify truck costing time.
Liao (2017)	Santos- Brazil	Compared theoretical model 'stochastic queuing model' and analytical tool ' simulation model' to shorten loading/unloading truck at docks

3. Problem definition

Port operations are difficult to derive analytically. For this reason, simulation models have been developed in maritime transportation. Most of them do not represent the whole infrastructure and/or operations and they can be classified in groups as port/terminal operations and logistics, vessel traffic. Simulation is a process of analysis and synthesis, useful as a tool to aid decision making in complex productive processes. By closer attention of inputs of modeling vessel arrivals in ports and observing the resulting outputs, were valuable insight may be obtained into which variables are most important and how variables interact to reinforce analytic solution methodologies. Therefore, it is understood as simulation of all the process of elaboration of a computational model representative of a real (or hypothetical) system and the conduction of experiments in order to understand the behavior of a system.

Traffic rules can allow changes to them. A control and traffic verification agent has been shown to be relevant and should be considered. The more detailed these rules are, the more accurate the results will be. It might also help to identify hidden traffic management problems behind simulation results and new traffic management strategies could be implemented.

4. Methodology of Simulation Model:

Simulation model is the decision making tool which imitates the operation of a real-world process or system over time, Simulation enables the study of and experimentation with the internal Interactions of a complex system, or of a subsystem within a complex System. Informational, organizational and environmental changes can be simulated and the effect of those alternations on the model's behavior can be observer. The knowledge gained in designing a simulation model can be of great value toward suggesting improvement in the system under investigation.

5. The proposed Model

The System is affected by changes occurring outside the system such as some factors would affect arrival of vessels this relationship considered an activity of a system as in Table 2 which presents the system activities

Table 2 The System Activities

System	Entities	Attributes	Activates	Events	State/Variables
Sea Ports	Vessels	Marking arrival times	Berthing, Runways	Arrivals, Departures, Vessel service time	Number of docks Number of / waiting vessels

Schedule of vessels to port for berthing one by one to be served with least service time so once vessel arrives till its departures as following Table 3 shows time between arrivals

Table 3 The Time between Arrivals Distribution

Time between arrivals (Days)	Frequency	Probability	Cumulative probability	Radom Digit Assignment
0	879	0.58	0.58	00-57
1	469	0.31	0.90	58-89
2	155	0.10	1.00	90-99
Total	1503	1.00	-	-

This randomness is simulated in Excel by generating random numbers in compliance with a determined probability distribution (Poisson, Exponential, normal, Weibull, etc.). The amount of vessel calls sea ports generated in the model, for the period, should converge to the value defined by the arrival rate. The average time vessel takes berthing showed as below in Table 4.

Table 4 Service time Distribution

Service Time (Days)	Frequency	Probability	Cumulative Probability	Random Digit Assignment
Small / 1.5	141	0.11	0.11	00-10
Medium/ 2	336	0.25	0.36	11-35
Large / 3	861	0.64	1.00	36-99
Total	1338	1.00	-	-

Table 4 is designed specifically for a double-channel queue dock with 3rd general dock which is used in case of emergency that both main container docks are busy which serves vessels on a first-in, first-out (FIFO) basis. It keeps track of the clock time at which each event occurs. The second column of Table 2 records the clock time of each arrival event, while the last column records the clock time of each departure event Sokhna port.

Simulation is used when it is not possible to experiment with the real system (for example, to the time required to perform the experiment, or to the high cost of the experiment, or to the difficulty of physically carrying the experiment (Liao, 2017). This is also the great advantage of simulation, allowing real studies of systems without modifying them, with speed and low cost when compared to the real physical and organizational changes necessary to study the same alternatives of future scenarios.

Finally, another extremely important parameter is how many replications / rounds or samples of the simulation will be made. As in simulation random variables are provided using probability distributions, running the simulation for just one day does not mean that on that day we will have a "typical" day

Another important factor for analysis of the solution is the average occupation rate of the docks, the curves of the mean time and total time in the system as a function of the average occupancy rate provide a curve that closely resembles the theoretical model; the curve has an exponential behavior at the beginning tending to linearity as the number of door increases. It does not make any difference to have more doors to receive loads, because their occupancy rate reaches almost 50% of the total capacity.

Table 5 shows the average of total time of use the docks after closing of the time window of 8 hours for vehicle reception which represents vessel simulation arrivals.

Table 5 The Results of Simulated Vessel Arrival Mode

Simulation Table for Vessel's Arrival

Vessels	RN1	Time between arrivals	Arrivals	RhE	Vessel Capacity	Service Time	Service Beginning	Server Doc kfLane	Waiting Time	Service Ending	Total Time
1	52	0	0	39	L	3	0	1	0	3	3
2	38	0	0	23	M	2	0	2	0	2	2
3	53	0	0	82	L	3	0	3	0	3	3
4	66	1	1	36	L	3	1	2	1	4	4
5	98	2	3	10	S	1.5	3	1	0	4.5	1.5
6	47	0	3	66	L	3	3	3	0	6	3
7	90	2	5	50	L	3	5	2	0	8	3
8	43	0	5	51	L	3	5	1	0	8	3
9	34	1	6	95	L	3	6	3	0	9	3
10	98	2	3	85	L	3	8	2	0	11	3
11	24	0	3	23	M	2	8	1	0	10	2
12	34	0	3	22	M	2	8	3	1	11	3
13	81	1	9	21	M	2	9	1	1	12	3
14	53	0	9	93	L	3	9	2	2	14	5
15	91	2	11	22	M	2	11	3	0	12	2
16	51	0	11	34	L	3	11	1	1	15	4
17	37	1	12	10	S	1.5	12	3	0	13.5	1.5
18	TO	1	13	34	L	3	13	3	05	16.5	3.5
19	as	1	14	36	L	3	14	3	0	17	3
20	94	2	16	25	M	2	16	2	0	18	2
21	98	2	18	14	M	2	18	1	0	20	2
22	59	1	19	51	L	3	19	3	0	22	3
23	56	0	19	43	L	3	19	2	0	22	3
24	92	2	21	34	M	2	21	1	0	23	2
25	33	0	21	9	S	1.5	21	2	1	23.5	2.5
26	24	0	21	22	M	2	21	3	1	24	3
27	60	1	22	19	M	2	22	1	1	25	3
23	46	0	22	55	L	3	22	2	15	26.5	4.5
29	64	1	23	91	L	3	23	3	1	27	4
30	26	0	23	36	L	3	23	1	2	28	5
31	36	1	24	6	S	1.5	24	2	25	28	4
32	30	0	24	72	L	3	24	3	3	30	6
33	93	2	26	53	L	3	26	1	2	31	5
34	22	0	26	18	M	2	26	2	2	30	4
35	99	2	23	44	L	3	23	2	2	33	5
36	60	1	29	65	L	3	29	3	1	33	4
37	1	0	29	91	L	3	29	1	2	34	5
38	93	2	31	23	M	2	31	2	2	35	4
38	17	0	31	36	L	3	31	3	2	36	5
40	60	1	32	45	L	3	3	1	2	37	5
Sum			32				102	602		765.5	136.5
Average			0.8				2.55	15.05		19.1375	3.4125

6. Recommendations Analysis and results

Since the simulation is based on the time that mainly measures the average total time starting from arrival till departure. After closer observation of the outcome and its comparison to objective, some aspects hereby found as follows:

- The average of inter arrival time of each Vessel is almost one day as per 40 runs 0.8 ~1.
- The average of waiting time almost one day/40 runs 0.8625 ~1.
- The average of total time of each Vessel is almost 3 days and 12 hours as per 40 runs
- The average of service time of each Vessel is almost 2 day and 12 hours per 40 runs. The average of service ending time of each Vessel is almost 19 day as per 40 runs 0.8 ~1.

7. Conclusion

In this paper, the vessel simulation model is built on real life data. We recognize the main features of system that affecting on tardiness. The performance can be improved and optimized through applying the recommendations to the operations in container terminals.

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