JPB REVIEW
INTERNATIONAL JOURNAL OF PROFESSIONAL BUSINESS REVIEW
ISSN: 2525-3654
OPEN ACCESS

A MULTI-OBJECTIVE DE NOVO PROGRAMMING MODELS: A REVIEW

Iftikhar Ali Hussein[A], Hegazy Zaher[B], Naglaa Ragaa Saeid[C], Heba Sayed Roshdy[D]

ARTICLE INFO

Article history:

Received 01 October 2023

Accepted 04 January 2024

Keywords:

De Novo Programming;
Deterministic Model (Certainty);
Linear Programming;
Multi-Objective Linear Programming;
Uncertainty Model.

ABSTRACT

Purpose: In this article, the published articles of this type of programming (DNP) were reviewed and classified according to the conditions of its use into two types: 1) De Novo programming under certainty, 2) De Novo programming under uncertainty, and the second type has been classified into four types: 1) Interval de novo programming, 2) Fuzzy de novo programming, 3) Type-II Fuzzy de novo programming, 4) Stochastic de novo programming, in addition to that, the articles were classified according to the author's, years of publication, type of (DNP) model, solution approach, validation and field of application.

Theoretical Framework: Most of the methods used in operations research focus on maximizing or optimizing existing available systems, but there are other suggested methods and methodologies that have been applied to design new systems such as De Novo programming, so there is a difference between improving an available system and designing an improved system.

Design/Methodology/Approach: We analyzed the De novo programming from 2017 to 2023. We identified when, who, where and what was published on the subject.

Findings: The results of this study resulted in a number of conclusions, including: that all the proposed models in the improvement of the De Novo programming model seek to design an optimum system by removing trade-offs between goals and redesigning the model. Through the articles reviewed and especially the uncertainty in the model, the researchers used fuzzy programming the most in addressing the uncertainty of FDNP: reaching 31%, either SDNP: 5%, FIDNP: 3% and IDNP: 3%.

Research, Practical & Social Implications: We suggest a future research agenda and highlight to the methods that used to solve DNP under certainty and uncertainty.

Originality/Value: The results indicate that the number of publications is growing, and the application of de Novo programming in the fields of (agriculture, industry and irrigation) more than the rest of the fields.

Doi: https://doi.org/10.26668/businessreview/2023.v9i1.4180

MODELOS DE PROGRAMAÇÃO MULTI-OBJETIVOS DE NOVO: UMA REVISÃO

RESUMO

Propósito: Neste artigo, os artigos publicados deste tipo de programação (DNP) foram revisados e classificados de acordo com as condições de seu uso em dois tipos: 1) Programação de De Novo com certeza, 2) Programação de De Novo com incerteza, e o segundo tipo foi classificado em quatro tipos: 1) Programação de Intervalo de novo, 2) Programação de Fuzzy de novo, 3) Programação de Fuzzy de novo tipo-II, 4) Programação estocástica de novo,

[A] *Lecturer at Middle Technical University, Technical Engineering College Baghdad. Baghdad, Iraq. E-mail: eftekhar.ali@mtu.edu.iq Orcid: https://orcid.org/0000-0003-3646-8054*
[B] *Prof. Dr. Department of Operations Research, Faculty of Graduate Studies for Statistical Research, Cairo University. Giza, Egypt. E-mail: hgsabry@yahoo.com Orcid: https://orcid.org/0000-0002-2295-3537*
[C] *Prof. Dr. Department of Operations Research, Faculty of Graduate Studies for Statistical Research, Cairo University. Giza, Egypt. E-mail: naglaa777subkiii@yahoo.com Orcid: https://orcid.org/0000-0002-5646-2832*
[D] *Asst. Prof. Dr. Department of Operations Research, Faculty of Graduate Studies for Statistical Research, Cairo University. Giza, Egypt. E-mail: hmhmdss@yahoo.com Orcid: https://orcid.org/0000-0002-9248-1392*

além disso, os artigos foram classificados de acordo com o autor, anos de publicação, tipo de modelo (DNP), abordagem de solução, validação e campo de aplicação.
Estrutura Teórica: A maioria dos métodos utilizados na pesquisa de operações se concentram em maximizar ou otimizar os sistemas disponíveis existentes, mas há outros métodos e metodologias sugeridos que foram aplicados para projetar novos sistemas, como a programação De Novo, de modo que há uma diferença entre melhorar um sistema disponível e projetar um sistema aprimorado.
Projeto/Metodologia/Abordagem: Analisamos a programação De novo de 2017 a 2023. Identificamos quando, quem, onde e o que foi publicado sobre o assunto.
Constatações: Os resultados deste estudo resultaram em uma série de conclusões, incluindo: que todos os modelos propostos na melhoria do modelo de programação De Novo buscam projetar um sistema ideal, eliminando os dilemas entre as metas e redesenhando o modelo. Pelos artigos revisados e principalmente pela incerteza no modelo, os pesquisadores mais utilizaram a programação difusa para abordar a incerteza de FDNP: alcançando 31%, ou SDNP: 5%, FIDNP: 3% e IDNP: 3%.
Investigação, Implicações Práticas e Sociais: Sugerimos uma agenda de investigação futura e destacamos os métodos que usaram para resolver o DNP sob certeza e incerteza.
Originalidade/Valor: Os resultados indicam que o número de publicações está crescendo, e a aplicação da programação de Novo nos campos de (agricultura, indústria e irrigação) é maior do que o resto dos campos

Keywords: Programação De Novo, Modelo Determinístico (Certeza), Programação Linear, Programação Linear Multiobjetivo, Modelo de Incerteza.

MODELOS DE PROGRAMACIÓN DE NOVO MULTIOBJETIVO: UNA REVISIÓN

RESUMEN
Objetivo: En este artículo se revisaron los artículos publicados de este tipo de programación (DNP) y se clasificaron de acuerdo a las condiciones de su uso en dos tipos: 1) Programación De Novo bajo certeza, 2) Programación De Novo bajo incertidumbre, y el segundo tipo se ha clasificado en cuatro tipos: 1) Programación Interval de novo, 2) Programación Fuzzy de novo, 3) Programación Fuzzy de novo Tipo II, 4) Programación estocástica de novo, además de que, los artículos se clasificaron de acuerdo con el autor, años de publicación, tipo de modelo (DNP), enfoque de solución, validación y campo de aplicación.
Marco Teórico: La mayoría de los métodos utilizados en la investigación de operaciones se centran en maximizar u optimizar los sistemas disponibles existentes, pero hay otros métodos y metodologías sugeridos que se han aplicado para diseñar nuevos sistemas como la programación De Novo, por lo que hay una diferencia entre mejorar un sistema disponible y diseñar un sistema mejorado.
Diseño/Metodología/Enfoque: Analizamos la programación De novo de 2017 a 2023. Identificamos cuándo, quién, dónde y qué se publicó sobre el tema.
Hallazgos: Los resultados de este estudio arrojaron una serie de conclusiones, entre ellas: que todos los modelos propuestos en la mejora del modelo de programación De Novo buscan diseñar un sistema óptimo eliminando las compensaciones entre los objetivos y rediseñando el modelo. A través de los artículos revisados y especialmente la incertidumbre en el modelo, los investigadores utilizaron la programación difusa más en abordar la incertidumbre del FDNP: alcanzando el 31%, ya sea SDNP: 5%, FIDNP: 3% e IDNP: 3%.
Investigación, Implicaciones Prácticas y Sociales: Sugerimos una agenda de investigación futura y destacamos los métodos que se utilizan para resolver el DNP bajo certeza e incertidumbre.
Originalidad/Valor: Los resultados indican que el número de publicaciones está creciendo, y la aplicación de la programación de Novo en los campos de (agricultura, industria y riego) más que el resto de los campos

Palabras clave: Programación de Novo, Modelo Determinístico (Certeza), Programación Lineal, Programación Lineal Multiobjetivo, Modelo de Incertidumbre.

INTRODUCTION

Traditional linear programming problems (LPP) (Kunwar and Sapkota ,2022); (Bhatia and Rana, 2020); (Tantawy, 2019) accomplish a single objective based on certain decision variables and constraints. The quantity of resources in each constraint is instead specified using the values of the choice variables. LPP can be written in more efficient notation as:

$$Maximize \qquad f = \sum_{j=1}^{n} c_j x_j$$
$$subject\ to: \ \sum_{j=1}^{n} a_{ij} x_j \leq b_i$$
$$x_j \geq 0 \qquad (1)$$

Where:

$j = 1,2, \dots, n \quad i = 1,2, \dots, m$, the decision variables x_j represent a level of competing activities, see1.

Methods for solving classic LPP: Simplex method (Hussain et al., 2019), Graphical method (Nalini et al., 2020), Big-M method (Cococcioni. & Fiaschi,2021), II-phase, and R method (Jose M, et al., 2015).

(Zeleny,2011) demonstrated that after resolving the issue, one should focus on objective function values. The question "Are resource amounts used optimally?" may be more helpful in focusing on the number of constraint resources used optimally. All of the problem's functions would need to be interpreted find a solution.

Zeleny developed a novel method known as "optimal system design" or "DNP" to solve single objective linear programming (SOLP) and multi-objective linear programming (MOLP), DNP using a "budget," This technique allows for the re-organization of resource levels. The main distinguishing feature of DNP is its capacity to rearrange resource amounts of restrictions in accordance with financial constraints (Zeleny,2011).

All of the resource levels of the constraints are completely used with this restructure. It provides the best model for resource utilization. A modified SOLP/MOLP paradigm might thus be used to study DNP. MOLP problems can also be resolved using the "de novo" theory. The execution of "an ideal system design" for MOLP, however, is a drawn-out process; more details see (Babic et al., 2017).

The goal of this paper is present a comprehensive and up-to-date review of the multi-objective de novo programming problem in case (certainty and uncertainty), including its concepts, improvements to the de novo programming model, latest implementations, etc. based on the relevant research achievements of the last seven years. This paper is organized as follows: Section 2 briefly illustrates the model of multi-objective programming problems (MOP) and methods for solving them; Section 3. Multi-objective de novo programming problems (MODNP) and methods for solving MODNP, Section 4. Classification of DNP by model type (certainty and uncertainty) and explain types of DNP under uncertainty, and Section 5. presents a DNP models analysis and a classification of models DNP according to (Author, Years, Type of parameters model, type of model, solution approach, and validation). The paper concludes with the most important conclusions.

THEORETICAL REFERENTIAL

Multi-objective linear programming (MOLP) is a model for optimizing a given system under multi-objectives. In MOLP problems, it is impossible to optimize all the objectives in the system simultaneously. The goal of trade-offs is to achieve satisfaction between the objectives. The MOLP model can be described as follows (Saini &Saha, 2021); (Trikolaee et al., 2019):

$$max\ f_k = \sum_{j=1}^{n} C_{kj}\, X_j, \qquad \mathrm{k} = 1,2, \dots, l,$$

$$subject\ to:$$

$$\sum_{j=1}^{n} a_{ij}\, X_{j_i} \leq b_i, \quad i = 1,2, \dots, m,$$

$$X_j \geq 0, j = 1,2, \dots, n \qquad (2)$$

The parameters b_i $(i = 1,2, \dots, m)$ represent the given available resources as constants.

Methods for solving MOLP

Goal programming by (Colapinto et al., 2020).

Weighted sum method presented by (Odu, 2019); (Li et al., 2020).

Epsilon-constraint method used by (Cafiedo, 2020); (Nikas, 2022).

Sen’s method introduced by (Sen, 2020).

Gradient method utilized by (Bisuiki et al., 2020).

Distance method used by (Kamal et al., 2018)

Fuzzy Delphi method used by (Rawia et al., 2021)

METHODOLOGY

Multi-objective De Novo Programming Problem (MODNP): is commonly used to design an optimal system by extending existing resources (if necessary) rather than finding the optimal strategy in a given system with fixed resources.

The provided accessible resources are constants by the parameters b_i in this situation. After; solving the MOLP model, the efficient solution concept is produced. The same constraint functions are used to support several competing objective functions that are used to solve numerous objective DNP or MOLP problems. This is how multiple objective DNP is demonstrated mathematically:

$$
\begin{aligned}
& max\ f_k = \sum_{j=1}^{n} C_{kj} X_j, \qquad \text{k} = 1,2, \dots, l, \\
& subject\ to: \\
& \sum_{j=1}^{n} a_{ij} X_{j_i} \le b_i, i = 1,2, \dots, m, \\
& \sum_{j=1}^{m} p_i b_i \le B, \\
& X_j \ge 0, j = 1,2, \dots, n
\end{aligned} \tag{3}
$$

X_j**,** and b_i are decision variables selection of available projects and resources ***pi*** respectively. ***B*** given the value of the support unit ***i*** and the total budget available, where **Z**: maximizing the profit of one or more objective problems. The challenge now is to develop an asset portfolio that has generated growth. Product value combination (given the unit price of ***m*** resources and given the total available budget) more details see (Banik &Bhattacharya, 2022); (Bhattacharya & Chakraborty, 2018).

Method for solving MODNP

a) Meta-optimum method

The meta-optimum problem can be formulated as follows:

$$
\begin{aligned}
& Min\ \ Z = VX \\
& subject\ to: \qquad CV \ge f^* \\
& X \ge 0
\end{aligned} \tag{4}
$$

Solving Problem 4 provides the solution:

$$X^* \quad , B^* = VX^* \quad ,b^* = AX^*$$

The value B^* identifies the minimum budget to achieve f^* through X^*,and b^*.
(Brozova & Vlach, 2019); (Casas et al.,2023).

b) Optimal path-ratios method

The optimum-path ratio represents an effective and fast tool for the efficient optimal redesign of large-scale linear systems. It is possible to define six types of optimum-path ratios as shown below: (Shi, 1995)

1- $$ratio_1 = \frac{B}{B^*} \tag{5}$$

2- $$ratio_2 = \frac{B}{B^{**}} \tag{6}$$

3- $$ratio_3 = \frac{\sum_i \alpha_i B_i^j}{B^{**}} \tag{7}$$

4- $$ratio_4 = \frac{B}{B^{**}} \tag{8}$$

5- $$ratio_5 = \frac{\sum_i \alpha_i B_i^j}{B^*} \tag{9}$$

6- $$ratio_6 = \frac{\sum_i \alpha_i B_i^j}{B^{**}} \tag{10}$$

c) Optimal system design

It is a set of designs that can be found through optimum-path ratios (5,6,7,8,9, and 10). The following optimum system designs can be determined:

(i) $$x^1 = ratio^1 x^{**}, \quad b^1 = ratio^1 b^{**} \quad and \;\; f^1 = ratio^1 f^{**} \tag{11}$$

(ii) $$x^2 = ratio^2 x^{**}, \quad b^2 = ratio^2 b^{**} \quad and \;\; f^2 = ratio^2 f^{**} \tag{12}$$

(iii) $$x^3 = ratio^3 x^{**}, \quad b^3 = ratio^3 b^{**} \quad and \;\; f^3 = ratio^3 f^{**} \tag{13}$$

(iv) $$x^4 = ratio^4 x^{*}, \quad b^4 = ratio^4 b^{*} \quad and \;\; f^4 = ratio^4 f^{*} \tag{14}$$

(v) $x^5 = ratio^5 x^*, \quad b^5 = ratio^5 b^* \quad and \;\; f^5 = ratio^5 f^*$ (15)

(vi) $x^6 = ratio^6 x^{nd}, \quad b^6 = ratio^6 b^{nd} \quad and \;\; f^6 = ratio^6 f^{nd}$ (16)

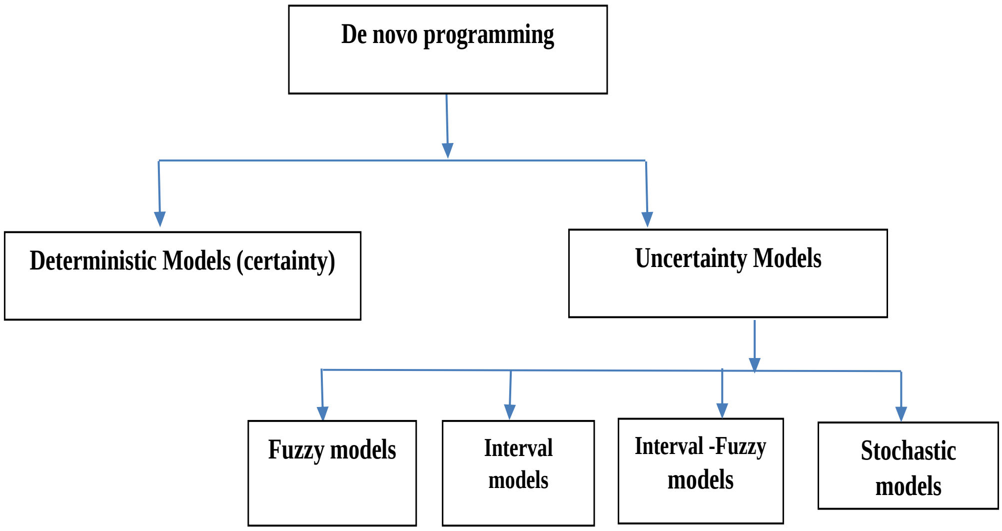
(Brozova & Vlach, 2019); (Tezenji et al., 2017).

RESULT & DISCUSSION

Classification of DNP by model type

An organizational system for classifying DNP model implementations is shown in Figure 1. A definition is given of the two major categories side by side, certainty models and uncertainty models categorized into (Fuzzy, Interval, Interval Fuzzy, and Stochastic); depending, on the two categories above, we will have five main types as shown in Figure 1 below:

Figure 1. The structure of De Novo programming models



Source: Prepared by authors.

De novo programming under certainty

In the literature, several researchers have dealt with articles on DNP models by assuming normal conditions (under certainty) as described below:

The authors have recently used DNP model in the metal industry's production planning to achieve optimization, by applying this technique to the manufacturing of metal containers to evaluate the effectiveness of the suggested model.

The researchers (Zhang & Hocine, 2018) used a multi-criteria DNP model and a meta-goal programming method to solve it.

The workers (Babic et al., 2018) have constructed a real-world business scenario by using DNP in place of linear programming.

Particular attention is paid by (Banik & Bhattachrya, 2018), suggesting a weighted goal programming to address MODNP issues.

In an article achieved by (Eni et al., 2018), used the prediction method and DNP implemented in ABC company where the model DNP gives an optimal profit.

A new approach has been proposed by (Faila, 2018) to project portfolio design based on a systematic combination of the DEA model and DNP optimization approach. The total available budget is a constraint on the project portfolio. The proposed model provides optimal project portfolio design with a minimal budget.

Min-max goal programming method is proposed by (Banik & Bhattachrya, 2020) for the MODNP issue employing positive and negative ideals.

A new approach Proposed by (Afli et al., 2019) has been successfully used for project portfolio design based on a systematic combination of the data envelope analysis (DEA) model and DNP optimization approach, the proposed model provides optimal project portfolio design with a minimal budget.

The previous study by (Broza &Vlach, 2019) generalized the DNP approach to finding the optimal design for a production system, so that there are more types of restrictions possible, in particular $' \geq', =$.

Lexical-objective programming has been used by (Umarusman, 2019) to find solutions to MODNP problems with positive ideal solutions.

MODNP problem has been solved by (Yusnita, 2019). He tried to evaluate the strategy and provide a better one, using one deviation variable, while Umarusman's method gives each objective restriction both positive and negative deviation variables.

The planning of urban parks has been examined by (Lo et al., 2020), which are crucial to the sustainability of cities; using DNP planning methods, the created model analyzed the three areas of ecological, economic, and social indicators for park design and evaluated the appropriateness of parks in Taichung City, Taiwan.

Researchers (Nath et al., 2020) applied MODNP formulation to solve budget optimization in the stock market, the proposed approach of them was illustrated through a real-world example based on data collected from the Bomba Stock Exchange (BSE).

The authors (Budianti et al., 2021); (Eny et al.,2022) applied DNP to PT.X company by formulating LPP to DNP and then solved the problem using by simplex method, DNP technique achieved optimal number of productions.

A broad approach has been tackled used by different authors (Susetyo et al., 2020); (Chen & Xiao, 2021) used MODNP with maximizing and reducing target types. The system offers a framework for obtaining the most targets at their ideal goal values (maximum/minimum) while also giving the DM freedom in determining the order in which the target occupations should be prioritized.

The workers (Mozafari et al., 2022); (Nikouei et al., 2022) used the DNP technique to determine the optimal product with a constraint budget.

De Novo programming under uncertainty

DNP under uncertainty models was divided into four main groups (Fuzzy DNP Models (FDNP), Stochastic DNP Models (SDNP), Interval DNP Models (IDNP), and Interval-Fuzzy DNP Models (IFDNP)), as follows.:

Fuzzy de novo programming models

Fuzzy Programming is an optimization paradigm that deals with optimization performance in the presence of uncertainty. This optimization technique is used when determination of system performance parameters and decision variables is not possible. Specifically, the truth values associated with the system can be strictly false (0), strictly true (1), or some value between the two extremes. This aims to get the concept of partial truth. One way to calculate the uncertainty in a system is to model the uncertainty using probability distributions, also known as statistical analysis. However, sometimes uncertainty is sometimes described using qualitative adjectives, or 'Fuzzy' statements, such as young or old and hot or cold, because exact boundaries do not necessarily exist (Khalifa, 2018).

Fuzzy Programming is built on the concept of Fuzzy Logic. The motivation for Fuzzy Logic, or more precisely Fuzzy Set Theory, is to accurately model and represent real-world data that is often 'Fuzzy' due to uncertainty. Number of factors such as inaccuracy in measuring tools or due to the use of ambiguity language (Saeid et al., 2018).

Some authors (Zaher et al., 2018); (Umarusman, 2018a; 2018b; 2020); (Banik & Bahttacharya, 2019); (Chakraborty & Bahttacharya, 2022); (Kacprzyk, 2022a; 2022b) were suggested an improvement to the de novo programming problem model to be suitable for conditions of uncertainty by making the parameters(fuzzy) of the mathematical model, as shown below:

$$Max\ \tilde{f}_k(X) = \sum_{j=1}^{n} \tilde{c}_{kj} X_j \qquad k = 1, \dots, L$$

$$Min\ \tilde{w}_s(X) = \sum_{j=1}^{n} \tilde{c}_{sj} X_j \qquad s = 1, \dots, r$$

$$Subject\ to:\ \sum_{j=1}^{n} \tilde{a}_{ij} X_j \leq b_i \qquad i = 1, \dots, m$$

$$\sum_{i=1}^{m} \tilde{P}_i b_i = \tilde{B}$$

$$X_j \geq 0 \qquad j = 1, \dots, n \qquad (17)$$

Where

$\tilde{c}_{kj}$, $\tilde{c}_{sj}$, $\tilde{a}_{ij}$, $\tilde{P}_i$ and $\tilde{B}$ are the parameters of model F-DNP with fuzzy numbers on R , the membership functions are $\mu_{\tilde{c}_{kj}}, \mu_{\tilde{c}_{sj}}, \mu_{\tilde{a}_{ij}}, \mu_{\tilde{P}_i}$ and $\mu_{\tilde{B}}$

Many studies have almost exclusively focused on FDNP models, as follows: The fuzzy goal programming technique is applied by (Kalifa, 2018) to solve a multi-Criteria DNP (MDNLP). Researcher (Saied, et al., 2018) conducted further research on the fuzzy MODNP. They proposed rewriting the MOPP using undefined parameters.

A new modified model was suggested by (Khalifa, 2018) to the Choco-man company, where fuzzy coefficients are present in two objectives of the new multi-objective model (revenue and profit). They used the modified S-curve membership function, and after that, they solved the previous model by goal programming, which includes deviational variables as additional objectives to reduce deviations in goals.

A new method of DNP called linear programming has been proposed by (Umarusman, 2018) he creates the best system possible given the budgetary limitations assuming that the Fuzzy MOLP-based production plan for a real firm is the greatest distinguishing characteristic that it uses target function values gained with the upper and lower limits of the budget rather compared with the ideas of positive and negative ideal solutions.

Also, (Umarusman, 2018b) proposed a new approach looking at how to implement the optimal production plan for real work based on fuzzy multi-objective linear programming (FMOLP). The advantage of the proposed method is that it does not use the concepts of positive and negative optimal solutions, but uses the acquired target function values that related to the upper and lower limits of the budget.

Some authors (Banik & Bhattacharya, 2019) have also suggested a Min-max GP methodology for a one-step general DNP problem solution with all the parameters being fuzzy integers. The remedy that was found is effective. The current method is far more realistic than the traditional DNP with clear parameters.

(Umarusman, 2020) presented Min-Max method (MM) which can be used to attain a newly discovered fresh concept connected to an ideal design by applying GP and a fuzzy GP is known as the MM method. The budget constraint is framed as a goal for solving the problem. The findings imply that the Min-max GP and MM approaches yield the same results.

A fuzzy goal with fuzzy parameter models has been used by (, integrating positive and negative ideal solutions. He introduced a brand-new fuzzy DNP technique. The recommended method, which combined ambiguous resource unit pricing and fuzzy constraint amounts, was used to construct the vague budget.

A scientific worker (Kacprzyk, 2022a; 2022b) used DNP with fuzzy parameters and formulated the problem as Max or Min of some utility function.

Stochastic de novo programming model

Stochastic programming (SP), a popular method for solving optimization problems under uncertainty, is commonly used to chemical engineering problems, for example planning or process synthesis. The scenarios, which represent uncertain outcomes, greatly influence the solution of SP.

This model represents an effective way to improve DNP under uncertainty; previous studies indicate that this model can be applied to several fields.

The author (Khalifa, 2018) applied MODNLP using the coefficients for possibilistic goal functions. The problem's solution is developed utilizing effective and required criteria. The model can be written as follows:

$$Max\ f_k(X, C^K) = C^K y = \sum_{i=1}^{n} C_i^k\, y_i \qquad k = 1, \dots, s$$
$$subject\ to:$$
$$y \in Y, C_i^k \in (\tilde{C}_i^k)_\delta \qquad i = 1, \dots, n \qquad (18)$$

Where:

$\tilde{C}_i^k$ represents the δ-cut of possibilistic variables, under the assumption of convexity.

It was found that the proposed model is suitable for decision variables and constraints when the problem is increased.

Interval de novo programming model

Linear interval programming provides a tool for solving real-world optimization problems under-valued uncertainty. Instead of explicitly approximating or estimating the input data, the coefficients of the time-lapse program may independently within the given lower and upper bounds. (Gao et al., 2018)

IDNP models are one type of uncertainty programming, and several publications have appeared in recent years documenting IDNP models.

Based on the approach presented by (Gao et al., 2018), they designed an efficient electricity-allocation system under uncertainty using an interval DNP approach based on Monte Carlo simulations.

The mathematical formula of this IDNP model can be written as follows:

$$
\begin{aligned}
&Max\ or\ Min\ f = C^{l,U} X^{l,U} \\
&subject\ to: \\
&A^{l,U} X^{l,U} \leq b^{l,U} \\
&p^{l,U} b^{l,U} \leq B^{l,U} \\
&X^{l,U} \geq 0 \qquad (19)
\end{aligned}
$$

Where:

$C^{l,U}$, $A^{l,U}$, $b^{l,U}$, $p^{l,U}$, and $B^{l,U}$ interval coefficients of objective function and constraints which can be written as the follows: $[C_l, C^U]$, $[A_l, A^U]$, $[b_l, b^U]$, $[p_l, p^U]$, and $[B_l, B^U]$ all intervals have a lower bound and upper bound.

After the proposed model was converted into two sub-problems, each problem was solved separately using the optimum-path ratios method. It was observed that the proposed model gave satisfactory results.

Type-II Fuzzy de novo programming model

Type-II fuzzy linear programming assumes that the coefficients of the objective function, constraints and unknown decision variables are all centered around fuzzy numbers to a given base. The idea of centering fuzzy number and arithmetic operations them was introduced.

Several improved models have been proposed to solve the problem of DNP under uncertain conditions.

Interval-Fuzzy DNP models (I-FDNP) have been applied by (Sharahi & Damagjani, 2018), they proposed two concepts of source: one of them is uncertainty, while the other is named type II uncertainty interval, by using DNP to create goals to allocate resources and set goals.

Also, researchers (Gao et al., 2021) employed the interval fuzzy DNP (MC-IFDP) approach for land planning under uncertainty by using (Monte Carlo simulation is a mathematical technique that predicts the possible outcomes of an uncertain event. Computer programs use this method to analyze past data and predict future developments based on the choice of action); they applied MC-IFDP to Guangzhou's land- planning (China).

The mathematical model of type-IIFDNP:

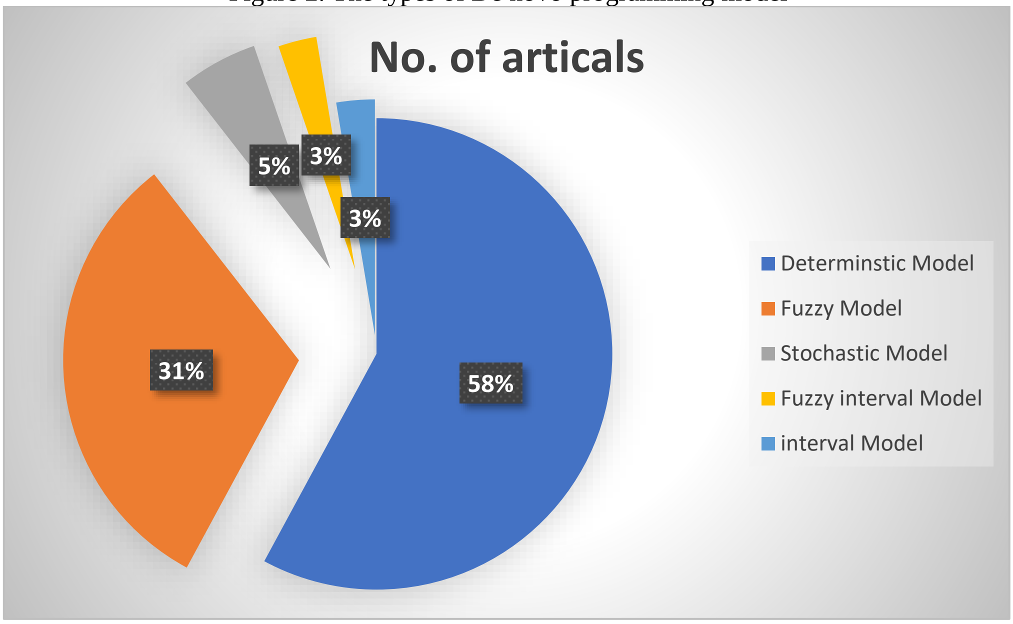
$$Min\ f = C^t x$$
$$subject\ to:$$
$$A.x \geq \tilde{b}$$
$$x \geq 0 \tag{20}$$

This type of model deals with Min f only.
(Yaquini. et al., 2023).

DNP Models Analysis

Figure 2 shows a graphical analysis of previous DNP studies describing the different types of DNP models from their origins. It also shows that 58% of studies using DNP under the assumption of certainty and 42% of studies using DNP under the premise of uncertainty. Among the DNP uncertainty models, we can classify the models as follows: (31% Fuzzy Models, 3% Interval Models, 3% Interval-Fuzzy Models and stochastic Models 5%).

Figure 2. The types of De novo programming model



Source: Prepared by authors.

According to previous studies about the applications of DNP models. Table 1 below classified the DNP model according to the type of model DNP, solution approach, and validation for some time from 2017 to 2023.

Table 1. Classify the DNP model according to type, solution approach, validation and field of application.

Author's	Year	Type of model DNP					Solution approach	Validation	Field of application
		Deterministic DNP	F-DNP	S-DNP	FI-DNP	I-DNP			
Babić et al.	2017						DNP	Case Study (CS)	Industry (Production planning)
Tezenji et al.	2017	✓					Bi-MODNP	CS	Inventory
Zhuang & Hocine	2018	✓					Meta goal programming, MCDNPP	CS	Industry (Production planning)
Faila	2018	✓					MODNP and DEA	Numerical Example (NE)	-
Babic et al.	2018	✓					LPDNP	NE	-
Banik & Bhattacharya	2018	✓					weighted goal programming technique, MODNPP	NE	-
Eni Y., et al.	2018	✓					DNP	CS	Industry (Production planning)
Khalifa	2018						MCDNP fuzzy goal	NE	-
Bhattacharya & Chakraborty	2018		✓				Luhandjula‟s compensatory $\boldsymbol{\mu\theta}$- operator	NE	-
Saeid et al	2018		✓				MOPP, fuzzy parameters	NE	-
Zaher et al.	2018		✓				S-curve membership function.	CS	Industry (Production planning)
Umarusman	2018		✓				Fuzzy theory set in DNP	NE	-
Umarusman	2018		✓				The Fuzzy Multi-Objective Linear Programming DNP	NE	-
Umarusman	2018		✓				DNP and F-goal programming	NE	-
Umarusman	2018		✓				Min-Max method	NE	-
Gao et al.	2018					✓	Monte-Carlo-based IDNP	CS	Urban planning
Afli F. et al.	2019	✓					MODNP and Goal programming	NE	-
Brozova & Vlach	2019	✓					G-DNP	NE	-
Khalifa	2019	✓					MODNLP	NE	-
Umarusman N.	2019	✓					MODNLP	NE	-
Yusnita E.	2019	✓					DNP and Forecasting	CS	Industry (Production planning)
Banik & Bhattacharya	2019		✓				One-step method	NE	-
Sharahi & Damghani	2019		✓				Interval type-II fuzzy	NE	-
Khalifa	2019				✓		MODNLP	NE	-
Lo et al.	2020	✓					DNP	CS	Metroplan planning

Author's	Year	Type of model DNP					Solution approach	Validation	Field of application
		Deterministic DNP	F-DNP	S-DNP	FI-DNP	I-DNP			
Nath J., et al.	2020	✓					DNP	CS	Marketing
Susetyo, J.	2020	✓							
Susanta & Bhattacharya	2020	✓					min-max goal programming, MODNPP	NE	-
Umarusman	2020		✓				FDNP	NE	-
Banik &Bhattacharya	2021	✓					A general method, MODNP with Min and Max	NE	-
Chen et al.	2021	✓					MODNP	CS	Cloud computing
Banik &Bhattacharya	2022	✓					General MODNP	NE	-
Enny A., et al.	2022	✓					DNP	CS	Industry (Production planning)
Kacprzyk	2022		✓				FDNP (dynamic and static)	NE	-
Kacprzyk	2023		✓				FDNP	NE	-

Source: Prepared by authors.

From above Table 1, it was found that all suggested models of DNP under uncertainty give a good result when using a few numbers of variables, it was found some difficulties in dealing with these proposed models when using a large number of variables. So, it must need to prepare a program for each proposed model; while, some studies were used numerical example and the little-used real case study, means, it was difficult to apply DNP under uncertainty for practical jobs due to the fact, that mathematical numerical model contains a large number of variables. Based on those as mentioned above, a comparison can be made between (LPP, MOLP, and DNP) models through Table 2. It is as the following:

Table 2. A comparison between (LPP, MOLP, and DNP) models.

	LPP	MOLP	DNP
1	One objective function Maximize good things (Profit, Revenue, **Sales, ...**ats). Or minimize bad things (Costs, Loss, …ats).	Multi objective Multi-goals in same time.	One objective or multi-objective.
2	Objective function may be Max or Min.	Multi-Objective function may be Max or Min or (Max and Min).	DNP maybe Max or Min or (Max and Min).
3	Used for relatively simple systems.	Used for relatively complex systems	Used for relatively complex systems.
4	By solving LP, we reach to optimal solution/ best solution.	By solving MOLP we reach to compromise solution/ most acceptable solution/ near optimal solution find this because of conflicts between the objectives.	By DNP we reach optimal system design
5	We want to find the values for decision variables that maximize or minimize the objective function value.	We want to find the values for decision variables that satisfies our gools as much as possible.	Structure design, meta-optimal solution and synthetic optimal solution.
6	Methods for solving LP are: Simplex method, Big-M method, R method, and Graphical method (if we have two decision variables), and open solver.	Methods for solving MOLP: Goal Programming, Weighted Sum Method, -Constraint Method, Chandra Sen Method, etc.	Zeleny approach, optimal-path ratios. Many proposed approaches of scientists are presented as in the review.

Source: Prepared by authors.

CONCLUSION

The DNP model is crucial in redefining the feasible region and achieving the ideal system design. It is clear from the assessment we have just given that these models may be used under either confidence or uncertainty. Applications of DNP provide trustworthy solutions, particularly for resource allocation issues. According to the analysis of the number of articles related to DNP under uncertainty, it was noticed that there are few compared to articles written under certainty.

REFERENCES

Afli, F., Hasbiyati, I., & Gamal, M. D. H, (2019), Modification goal programming for solving multi-objective de-novo programming problems. *IJMFS*, *5*(4), 64-69, https://doi.org/10.11648/J.IJMFS.20190504.11

Babić Z., Peric, T. & Mandic, Z. (2017), Optimization of production plan in the metal industry by the use of De novo programming. *IJAQ*, *45*(3). Belgrade, Serbia. http://dx.doi.org/10.25137/IJAQ.n3.v45.y2017.p23-27

Babic, Z., Veza, I., Balic, A., & Crnjac, M. (2018), Application of De Novo Programming Approach for Optimizing the Business Process. *IJSE*, *12*(5), 519-524. https://doi.org/10.1999/1307-6892%2F10008915

Banik, S, & Bhattacharya, D. (2019). One-step approach for solving general multi-objective De Novo programming problem involving fuzzy parameters. *HJMS*, *48*(6), 1824-1837. https://doi.org/10.15672/HJMS.2019.659

Banik, S., & Bhattacharya, D. (2018). Weighted goal programming approach for solving multi-objective de novo programming problems. *IJERCSE*, *5*(2), 316-322.

Banki, S. & Bhattacharya, D. A (2020), Note on min-max goal programming approach for solving multi-objective de novo programming problems. *Int. J. Operational Research*, *37*(1), 32–47. https://doi.org/10.1504/IJOR.2020.104223

Banki, S. & Bhattacharya, D. (2022). General method for solving multi-objective de novo programming problems. *J Math Meth Oper Res*, Published online: 16 Jun 2022. https://doi.org/10.1080/02331934.2022.2088367

Bhatia, M. & Rana, A. (2020), A Mathematical Approach to Optimize Crop Allocation – A Linear Programming Model. *IJDNE*, *15*(2), 245-252. https://doi.org/10.18280/ijdne.150215 .

Bhattacharya, D. &. Chakraborty, S. (2018). Solution of the general multi-objective De-Novo programming problem using compensatory operator under fuzzy environment. *International Journal of Physics: Conference Series*, *1039*, 27-29. https://iopscience.iop.org/issue/1742-6596/1039/1

Bisuiki, N. K., Mazumader, S. & Panda, G. A (2020), Gradient-Free Method for Multi-objective Optimization Problem. *Optimization, Variational Analysis and Applications*, *355*, 19-34. http://dx.doi.org/10.1007/978-981-16-1819-2_2

Brozova H., & Vlach M. (2019). Optimal design of production systems: meta optimization with generalized de novo programming. *International Conference on Operations Research and Enterprise Systems*, 19 Feb. 2019, 473-480, https://doi.org/10.5220/0007682404730480

Budianti, R. S., & Ramdani, Y. (2021). Optimasi Produksi Buis Beton Menggunakan Model De Novo Programming pada Sakti Beton Jaya Mandiri. *Jurnal Riset Matematika*, *1*(1), 46-56, 2021.

Cañedo, B. P., Verdegay J. L. & Pérez, R. M. (2020). An epsilon-constraint method for fully fuzzy multi-objective linear programming. *International journal of intelligent systems*, *35*(4), 600-624. https://doi.org/10.1002/int.22219

Casas, J. E. P., de Guzmán, C. A. N. N., & Pimentel, J. F. F. (2023). Quality Management in Bridge Development: Systematic Study and Bibliometric Analysis. *International Journal of Professional Business Review*, *8*(11), e04105. https://doi.org/10.26668/businessreview/2023.v8i11.4105

Chakraborty, S. & Bhattacharya, D. (2022). Fuzzy Approach to Solve General De-Novo Programming Problem. *Part of the Lecture Notes in Networks and Systems book series (LNNS), 415*, 181-192. http://dx.doi.org/10.1007/978-981-19-0179-9_10

Chen, J., Du, T. & Xiao, G. (2021). A multi-objective optimization for resource allocation of emergent demands in cloud computing. *JoCCASA*, *10*(20), 1-17. https://doi.org/10.1186/s13677-021-00237-7.

Cococcioni, M. & Fiaschi, L. (2021). *The Big-M method with the numerical infinite M*. Optimization Letters. 15:2455–2468. https://doi.org/10.1007/s11590-020-01644-6

Colapinto, C., Jayarman, R. & Torre, D. L. (2020). Goal Programming Models for Managerial Strategic Decision Making. Applied Mathematical Analysis: Theory, Methods, and Applications. In *Studies in Systems, Decision and Control* (SSDC, Vol. 177).

Eni, Y., Sepnivea, H., & Rudi. (2018*)*. Optimisation of resin production quality using de novo programming models. *Journal Social sciences & Humanities*, *26*(T), 307-320.

Enny, A., Bayu, S., & Sinta, D. (2022). *Production planning with de novo programming method to optimize profits at PT. Varia Usaha Beton Waru-Sidoarjo*. Waluyo Jatmiko national seminar on industrial engineering university of national development "Veteran" east Java.

Faila, P., (2018, 2 Aug). Project portfolio designing using data envelopment analysis and de novo optimization. *Central European Journal of Operations Research*, Springer-Verlag GmbH Germany, published online. https://doi.org/10.1007/s10100-018-0571-6

Gao, P. P., Li, Y. P., Sun, J. & Huang, G. H. (2018). A Monte-Carlo-based interval De Novo programming method for optimal system design under uncertainty. *IFAC*, *72*, 30-42. https://doi.org/10.1016/j.engappai.2018.03.010

Gao, P. P., Li, Y. P., Gong, J. W., & Huang, G. H. (2021). *Urban land-use planning under multi-uncertainty and multi-objective considering ecosystem service value and economic benefit - A case study of Guangzhou, China*. Elsevier Ecological Complexity, https://doi.org/10.1016/j.ecocom.2020.100886.

Hussain, M. R., Qayyum, M, & Hussain, M. E. (2019). Effect of Seven Steps Approach on Simplex Method to Optimize the Mathematical Manipulation. *IJRTE*, *7*(5), 34-43.

Jose, M., Oriol, L., & Vicenc, F. (2015). Modeling and solving linear programming with R. *Omnia Science (Omnia Publisher SL)*, ISBN: 978-84-944229-3-5. DOI: http://dx.doi.org/10.3926/oss.20

Kacprzyk, J. (2022), *On Some De Novo Type Approaches to Fuzzy Decision Making, Optimization and Control: An Application to Sustainable Regional Development*. 15th International Conference on Applications of Fuzzy Systems, Soft Computing and Artificial Intelligence Tools – ICAFS- https://doi.org/10.1007/978-3-031-25252-5_1

Kacprzyk, J. (2022). *Fuzzy Static and Dynamic De Novo Type Approaches to Optimal System Design*. Intelligent and Fuzzy Systems. INFUS Lecture Notes in Networks and Systems, vol 504. Springer, Cham. https://doi.org/10.1007/978-3-031-09173-5_1

Kamal, M., Jalil, S. A., Muneeb, S. M., & Ali, I. (2018). A Distance Based Method for Solving Multi-Objective Optimization Problem. *JMASM*. *17*(1), 1-23. https://dx.doi.org/10.22237/jmasm/1532525455

Khalifa H. (2018). On Solving Fully Fuzzy Multi-Criteria De Novo Programming via Fuzzy Goal Programming Approach. *JARIE*, *5*(3), 239–252. http://dx.doi.org/10.22105/jarie.2018.148642.1054

Khalifa, H. A. (2019). On Solving Possibilistic Multi- Objective De Novo linear Programming. *IJO*, *11*(2), 277-284 https://dorl.net/dor/20.1001.1.25885723.2019.11.2.16.7

Kunwar, R., & Sapkota, H. P. (2022). An introduction to linear programming problems with some real-life applications. *EJ-MATH, European Journal of Mathematics and Statistics*, *3*(2), 21-27. DOI: http://dx.doi.org/10.24018/ejmath.2022.3.2.108

Li, Y., Yang, Q., Chang, T., Qin, T. & Wu, F. (2020). Multi-load cases topological optimization by weighted sum method based on load case severity degree and ideality. *Advances in Mechanical Engineering*, *12*(8), 1–15. https://doi.org/10.1177/1687814020947510

Lo, W. C., Lu, C. H., & Chou, Y. C. (2020). Application of Multi-Criteria Decision Making and Multi-Objective Planning Methods for Evaluating Metropolitan Parks in Terms of Budget and Benefits. *Mathematics*, *8*(1304), 1-17. http://dx.doi.org/10.3390/math8081304

Mediya, B. M., Ayad, M. R., Rzgar, F. M, & Ronak, M. A. (2020). A novel technique for solving multi-objective linear programming problems. *Mathematical Forum*, *28*(2), 155-165.

Mozafari, M. M., Falsafizade, N. A., & Sabouni, M. S.(2022). Determining the optimal crop pattern with emphasis on budget constraints: De-Novo programming evaluation in Zarghan plain of Fars Iran. *Energ. Ecol. Environ*, *7*, 489–507. https://doi.org/10.1007/s40974-021-00211-8

Nalini V., Smita R., Manoj, S. & Satyajit, S. (2020). Graphical view of quick simplex method to solve linear programming problem. *International Journal of Advanced Science and Technology*, *29*(6), 5694-5710.

Nath, J., Banik, S., & Bhatacharya, D. (2020). Portfolio optimization in share market using multi-objective linear programming. *International Journal of Mathematics and Computer Research*, *8*(8), 2121-2123. https://doi.org/10.47191/IJMCR%2FV8I8.02

Nikas, A. Fountoulakis, A. Forouli, A. & Haris Doukas, H. (2022). A robust augmented ε-constraint method (AUGMECON-R) for finding exact solutions of multi-objective linear programming problems. *Operational Research*, *22*, 1291-1332. https://doi.org/10.1007/s12351-020-00574-

Nikouei, A., Asgharipour, M. R., & Marzban, Z. (2022). Modeling land allocation to produce crops under economic and environmental goals in Iran: a multi-objective programming approach. *J Ecological Modelling*, *471*, 2022. https://doi.org/10.1016/j.ecolmodel.2022.110062

Odu, G. O. (2019). Weighting methods for multi-criteria decision-making technique. *J. Appl. Sci. Environ. Manage*, *23*(8), 1449-1457. DOI: 10.4314/jasem.v23i8.7

Rawia, T. M., Razali, Y., Nurfadhlina, M. S., Rusli, A. (2021). Unifying the evaluation criteria of many objectives optimization using fuzzy Delphi method. *Baghdad Sci. J.*, *18*(4(Suppl.)), 1423-1430. http://dx.doi.org/10.21123/bsj.2021.18.4(Suppl.).1423

Saeid, N. R., Ahmad, I. H., & Mahmoud, M. A. (2018). *Design an Optimal System with Fuzzy Multiple Objective De Novo Programming Approach*. Cairo University, Institute of Statistical Studies and Research, The 53rd Annual Conference on Statistics, Computer Science and Operations Research.

Saini, N. & Saha, S. (2021). Multi-objective optimization techniques: a survey of the state-of-the-art and applications. *EPIS*, *230*(3), 2319-2335. https://doi.org/10.1140/epjs/s11734-021-00206-w

Sen, C. (2020). Sen's Multi-Objective Optimization (MOO) Technique – A Review. *IJMTST*, *06*(09), 208-210. https://doi.org/10.46501/IJMTST060931

Sharahi, S. J. &, Damghani, K. K. (2019). Fuzzy type-II De-Novo programming for resource allocation and target setting in network data envelopment analysis: A natural gas supply chain. *Expert Systems with Applications*, *117*, 312-329. https://doi.org/10.1016/j.eswa.2018.09.046

Shi Y. (1995). Studies on optimum-path ratios in multi-criteria De Novo programming problems. *Computers Math. Appl*. *29*(5), 43-50. https://doi.org/10.1016/0898-1221(94)00247-I

Susetyo, J., Asih, E. W., & Manullang, E. (2020, 21 November). *Optimization of production planning using the de novo model Programming with a Goal Programming approach to Bread Making Production*. Industrial Proceedings Engineering Conference (EIC). Department of Industrial Engineering, Faculty of Industrial Engineering, UPN "Veteran" Jogjakarta (pp. 264-270).

Tantawy, S. (2019). A New Procedure for Solving Linear Programming Problem with Sensitivity Analysis. *Trends Applied Sci. Res.*, *14*(1), 7-11. http://dx.doi.org/10.3923/tasr.2019.7.11

Tezenji, F. R., Mohammadi, M. & Pasandideh, S. H. R. (2017). Bi-objective location-allocation inventory-network design in a two-echelon supply chain using de novo programming. *NSGA-II and NRGA, I. J of Logistics Systems and Management*, *28*(3), 308-337. http://dx.doi.org/10.1504/IJLSM.2017.10007812

Tirkolaee, E. B., Goli, A., Hematian, M., Sangaiah, A. K., & Han, T. (2019). Multi-objective multi-mode resource constrained project scheduling problem using pareto-based algorithms. *Computing*, *101*, 547-570. https://doi.org/10.1007/s00607-018-00693-1

Torkayesh, A. E., Vandchali, H. R., & Tirkolaee, E. B. (2021). Multi-objective optimization for healthcare waste management network design with sustainability perspective. *Sustainability*, *13*(15), 1-17. https://doi.org/10.3390/su13158279

Turgut, O., Dalkiran, E. & Murat, A. E. (2019). An exact parallel objective space decomposition algorithm for solving multi-objective integer programming problems. *J. Global Optim*., *75*, 35–62. https://link.springer.com/article/10.1007/s10898-019-00778-x

Umarusman, N. (2018a). Fuzzy goal programming problem based on minmax approach for optimal system design. *The Journal of Operations Research, Statistic, Economic and Management Information Systems*, *6*(1), 177-189. http://dx.doi.org/10.17093/alphanumeric.404680

Umarusman, N. (2019). Using global criterion method to define priorities in Lexicographic goal programming and an application for optimal system design. *MANAS Journal of social studies*, *8*(1), 326-341.

Umarusman, N. (2020). *A new fuzzy de novo programming approach for optimal system design* (pp. 13-31). Faculty of Economics and Administrative Sciences, Aksaray University, Turkey Open Access. Published by De Gruyter. https://doi.org/10.1515/9783110628616-002

Umarusman, N. (2018b). A fuzzy approach proposal in the solution of multi objective de novo programming problem and business application. *BERJ*, *9*(4), 825-838. https://doi.org/10.20409/berj.2018.141

West, J. (2019). Multi-criteria evolutionary algorithm optimization for horticulture crop management. *J.agsy*, *173*, 469-481. https://doi.org/10.1016/j.agsy.2019.03.016

Yaquini Ticllacuri, de Osambela, J. E. S., & Pimentel, J. F. F. (2023). Application of Revit Software to Improve Spatial Intelligence in Architecture Students in a Private University – Huancayo. *International Journal of Professional Business Review*, *8*(10), e03882. https://doi.org/10.26668/businessreview/2023.v8i10.38822

You, X. & Hou, F. (2023). Multi-objective programming consensus model based on evolutionary game analysis in group decision making. *J. inffus*, *93*, 132-149. https://doi.org/10.1016/j.inffus.2022.12.024

Yusnita, E. (2019). Application of the de novo programming method for production planning optimization. *Journal of industrial and manufacture engineering*, *3*(2), 63-71.

Zaher, H., Saeid, N. R. & Solomon, M. (2018). *Solving Production Problem with Fuzzy Multi-Objective Using Goal Programming*. Cairo University, Institute of Statistical Studies and Research, The 53rd Annual Conference on Statistics, Computer Science and Operations Research, 3-5 Dec 2018.

Zeleny, M. (2011). Multiple criteria decision making (MCDM), from paradigm lost to paradigm regained? *J. MCDM*, *18*, 77-89. https://doi.org/10.1002/mcda.473

Zhuang, Z. Y., & Hocine, A. (2018). Meta goal programing approach for solving multi-criteria de Novo programing problem. *J. EJOR*, *265*, 228-238. https://doi.org/10.1016/j.ejor.2017.07.035