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RESEARCH ARTICLE

# Development of Complex Linear Diophantine Fuzzy Soft Set in Determining a Suitable Agri-Drone for Spraying Fertilizers and Pesticides

**VIMALA JAYAKUMAR[1], ASHMA BANU KATHER MOHIDEEN[1], MUHAMMAD HARIS SAEED[2], HAMED ALSULAMI[3], AFTAB HUSSAIN[3], AND MUHAMMAD SAEED[4]**

[1]Department of Mathematics, Alagappa University, Karaikudi, Tamil Nadu 630003, India
[2]Department of Chemistry, University of Management and Technology, Lahore 54770, Pakistan
[3]Department of Mathematics, King Abdulaziz University, Jeddah 21589, Saudi Arabia
[4]Department of Mathematics, University of Management and Technology, Lahore 54770, Pakistan

Corresponding author: Muhammad Saeed (muhammad.saeed@umt.edu.pk)

**ABSTRACT** The global agricultural sector is responsible for fulfilling the food requirements of the increasing population around the globe, alongside contributing to 28% of global employment. Drones are used for effective and efficient spray of fertilizers to reduce labor and the associated costs. Various drones are available in the market, each with pros and cons. The main aim of this paper is to select a suitable drone for spraying fertilizers in agri-land among the various attributes using a novel Complex Linear Diophantine Fuzzy Soft set algorithm. This novel concept is first introduced alongside its fundamental operations like $\oplus$ and $\otimes$. This hybrid structure has the properties of the Complex Linear Diophantine Fuzzy set and soft set. A decision-support system based on Complex Linear Diophantine Fuzzy Soft set was designed and applied on the multi-attribute decision making problem of selecting the best drone for spraying fertilizer on crops.

**INDEX TERMS** Precision agriculture, decision making, fuzzy set theory, linear diophantine.

## I. INTRODUCTION

The need for innovation is more than ever required in agriculture. The application of state-of -the-art technologies for agricultural purposes has increased over the years due to scientific development in the field of artificial intelligence, computer vision, and camera technology [1], [2], [3]. Mobile networks coupled with satellite technology, studies on organic and inorganic fertilizers and utilization of waste for agricultural purposes have also helped the agricultural sector grow [4], [5], [6]. Still, the industry faces considerable deficits in terms of revenue, shortage of labor and changes in consumer preferences for transparency and sustainability [7]. The agricultural demands are estimated to grow at alarming rates, with the estimated population of people growing to 9.7 billion by the end of 2050 [8]. The resources associated with agriculture, like global water consumption, fertilizer, and pesticide requirements, and tackling the environmental issues will be quite a considerable challenge. The need to develop innovative ways to reduce costs and generate greater yield while not harming the environment is more than ever required nowadays [10].

With these issues in mind, the terms smart agriculture and precision farming were introduced, referring to the use of information communication technologies and other mechanized cutting-edge technologies for an agricultural process for increased efficiency and efficacy [11], [12]. One of the technologies resulting from the above terms is developing and deploying agricultural drones for uniform fertilizer spraying to minimize fertilizer losses and lower labor costs. Sane Souvanhnakhoomman contributed his work for Review on Application of Drone in Spraying Pesticides and Fertilizers, which was given in [29].

Even though drones have been employed in literature for several applications (i.e., collecting image data, transport of goods, and herding of livestock), this paper aims for optimal

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selection of agricultural drones for fertilizer spraying purposes. Even though unmanned aerial technology has come a long way, there are still areas where these drones fall short (i.e., limited power, collision risk, limited payload delivery, high implementation costs) [8]. This presents itself as a multi-attribute decision-making problem to select the optimal drone based on the presented set of characteristics. Fuzzy set theory can be employed for addressing these problems as it allows for versatile data manipulation and tools to address uncertainties.

To accord with certain real-life problems, the concept of Fuzzy set($\mathscr{FS}$) given by Zadeh in [35] by using a Membership Grade($\mathscr{MG}$) whose value lies between [0, 1]. This would be one of the most effusive models in handling uncertainty. As an advancement of $\mathscr{FS}$, an idea of Intuitionistic Fuzzy set($\mathscr{IFS}$) was presented by Atanassov [16] which deals with the $\mathscr{MG}$ and Non-membership Grade($\mathscr{NMG}$) with the condition that sum of $\mathscr{MG}$ and $\mathscr{NMG}$ must be in [0, 1]. A particularization of q-Rung Orthopair Fuzzy set($q-\mathscr{ROFS}$) as a generalization of Intuitionistic Fuzzy Set ($\mathscr{IFS}$) was introduced by Yager [33] refreshing with the condition that the sum of $q^{th}$ power of $\mathscr{MG}$ and $\mathscr{NMG}$ should be in [0, 1]. By introducing the reference parameters into play, a notion of Linear Diophantine Fuzzy set($\mathscr{LDFS}$) was developed by Riaz and Hashmi [28].

In order to bring an additional expansion to the version of uncertainty and to associate the universal set with the parameter, Soft set ($\mathscr{SS}$) was interpreted by Molodsov [22]. Many researchers worked on the extension of $\mathscr{SS}$, which was given in [14], [31], and [13]. Samarandache [30] as a generalization of $\mathscr{SS}$ introduced a concept called Hypersoft set ($\mathscr{HSS}$) by adjusting the function into a multi-argument function. Saeed et al. [23] further studied the development of the Complex Multi-Fuzzy Hypersoft set and its applications in decision-making using similarity measures and entropy to deal with real-life problems involving 2-D information.

The idea of Soft Matrix($\mathscr{SM}$) were given by Naim and Serdar [24]. As a generalization of $\mathscr{SM}$, Yong and Chenli [34] introduced the notion of Fuzzy Soft Matrix($\mathscr{FSM}$). Rajareega and Vimala [26] has given the idea of Complex Intuitionistic Fuzzy soft Matrix ($\mathscr{CIFSM}$). Many of the analysts have worked on the development of $\mathscr{FS}$ and $\mathscr{SS}$ given in [17], [18], [19], and [25].

Some of the experimenters had an idea of taking the co-domain of $\mathscr{FS}$ to be a complex number instead of [0, 1]. As a result, Ramot et al. [27] gave an idea of defining Complex Fuzzy set ($\mathscr{CFS}$) which a Complex-Valued Membership Grade represented ($\mathscr{CVMG}$) i.e., $C(x) = \Theta(x)e^{i2\pi w_{\Theta}(x)}$ where $\Theta(x)$ is the amplitude term and $w_{\Theta}(x)$ is the phase term, imposed by the condition that both the amplitude term and the phase term must lie in [0, 1]. It is possible to illustrate every ordinary $\mathscr{FS}$ in terms of a $\mathscr{CFS}$ by assuming amplitude term equal to $C(x)$ and phase term equal to zero. The phase term is the distinctive factor between $\mathscr{FS}$ and $\mathscr{CFS}$, which also novelizes $\mathscr{CFS}$. Both the amplitude term and the phase term are crucial for $\mathscr{CVMG}$ as it helps to resolve many of the challenges faced in a 2-dimensional frame of reference. Alkouri and Salleh [15] introduced the notion of Complex Intuitionistic Fuzzy set ($\mathscr{CIFS}$) by a $\mathscr{CVMG}$ (i.e., $\Theta(x)e^{i2\pi w_{\Theta}(x)}$ and Complex-Valued Non-Membership Grade($\mathscr{CVNMG}$) (i.e., $\Lambda(x)e^{i2\pi w_{\Lambda}(x)}$ imposed by the condition that sum of amplitude term of $\mathscr{MG}$ and amplitude term of $\mathscr{NMG}$ should be in [0, 1] and also the sum of phase term of $\mathscr{MG}$ and phase term of $\mathscr{NMG}$ also lie in [0, 1]. Huseyin [20] developed the concept of Complex Linear Diophantine Fuzzy set($\mathscr{CLDFS}$) in terms of $\mathscr{CVMG}$ and $\mathscr{CVNMG}$ and Complex-Valued Reference Parameter.

### A. MOTIVATION AND OBJECTIVES

The main characteristics of $\mathscr{CLDFSS}$ includes

1) *Effectiveness of the Conception:* The proposed conception is effective and capable for all kinds of input data to deal with uncertainties. As compared to the existing theories, the space of proposed conception is enlarged due to the presence of reference parameters together with the use of parametrization tool in 2-dimensional frame of reference. In some Multi-Criteria Decision Making $\mathscr{MCDM}$ problem, different types of situations and input data are need to be accomplished. This proposed conception can be easily adapted on dealing with different type of real-life situations.
2) *Flexibility of the Proposed Algorithm:* The proposed algorithm is simply workable for different types of input data due to the presence of score formula. This method is more flexible because of the addition of reference parameter(which can be differentiated according to different situations) and parametrization tool.
3) *Supremacy and Comparison of Proposed Conception With Existing Methods:* $\mathscr{IFS}$ and $-\mathscr{ROFS}$ have some limitations on $\mathscr{MG}$ and $\mathscr{NMG}$. Linear Diophantine Fuzzt Set ($\mathscr{LDFS}$) fills this literature gap by introducing reference parameters. However, $\mathscr{LDFS}$ cannot deal with the real-life problems involving 2-D information. To address this research gap, $\mathscr{CLDFS}$ is developed, which helps in handling situations in a complex frame of reference. Although, $\mathscr{CLDFS}$ is incapable of dealing with parametrization tool. The proposed conception enhances the existing methods and helps the decision maker to freely choose $\mathscr{MG}$ and $\mathscr{NMG}$ without any limitations with the use of parametrization tool in a complex frame of reference.

With all these benefits concerned, the foremost objective of the paper is as follows:

1) A conception called Complex Linear Diophantine Fuzzy Soft set($\mathscr{CLDFSS}$) together with some of the operational laws and theorems were explored.
2) An algorithm is particularized for the feasibility of the proposed method.
3) A sample model has also been executed to select a suitable drone for spraying in agriculture together with its manufacturing date.

4) A comparative exploration has also been interpreted for the feasibility of the proposed conception.

Section II, "Preliminaries", presents a few of the fundamental definitions such as $\mathscr{SS}$, $\mathscr{CFS}$, $\mathscr{IFS}$, $\mathscr{CLDFS}$, $\mathscr{IFSS}$ and Accuracy function for $\mathscr{CLDFS}$. Section III, "Complex Linear Diophantine Fuzzy Soft set", confers a novel concept called Complex Linear Diophantine Fuzzy Soft set and some of its operational laws like $\oplus$ and $\otimes$ together with the theorems and proofs. In section IV titled "$\mathscr{CLDFSS}$-decision-making technique", we have developed an algorithm to select a suitable drone for spraying fertilizers. In section V titled "Comparative Exploration", the proposed conception has been compared with the existing methods for the feasibility of the concept proposed.

## II. PRELIMINARIES

In this section of the paper, certain rudimentary definitions like $\mathscr{SS}$, $\mathscr{CFS}$, $\mathscr{IFS}$, $\mathscr{CLDFS}$, $\mathscr{IFSS}$ and Accuracy function for $\mathscr{CLDFS}$ were interpreted to facilitate the framework of the paper. All through the paper, $\mathscr{H}$ symbolizes the universal set and $\mathscr{S}$ symbolizes the parameter set.

*Definition 2.1 [22]:* Let $P(\mathscr{H})$ called the power set of $\mathscr{H}$. Then the Soft set O is particularized on $\mathscr{H}$ as

$$O = \{(s, Q(s))/s \in \mathscr{S}, Q(s) \in P(\mathscr{H})\}$$

*Definition 2.2 [27]:* The Complex Fuzzy set P particularized on $\mathscr{H}$ as

$$P = \{(h_t, \langle \Theta_P(h_t)e^{i\Lambda_{\Theta_P}(h_t)}\rangle) : h_t \in \mathscr{H}\}$$

where $\Theta_P(h_t)e^{i\Lambda_{\Theta_P}(h_t)}$ (*for* $\Theta_P(h_t) \in [0,1], \Lambda_{\Theta_P}(h_t) \in [0, 2\pi]$) indicate the complex-valued grade of membership of $h_t \in \mathscr{H}$. As it could be reexamined as

$$P = \{(h_t, \langle \Theta_P(h_t)e^{i2\pi w_{\Theta_P}(h_t)}\rangle) : h_t \in \mathscr{H}\}$$

where $\Theta_P(h_t)e^{i2\pi w_{\Theta_P}(h_t)}$ (*for* $\Theta_P(h_t)$, $w_{\Theta_P}(h_t) \in [0,1]$) indicate the complex-valued grade of membership of $h_t \in \mathscr{H}$.

*Definition 2.3 [16]:* The Intuitionistic Fuzzy set Y particularized on $\mathscr{H}$ as

$$Y = \{(h_t, \langle \Theta_Y(h_t), \Lambda_Y(h_t)\rangle) : h_t \in \mathscr{H}\}$$

where $\Theta_Y(h_t), \Lambda_Y(h_t) \in [0, 1]$ represent respectively the grade of membership, non-membership of $h_t \in \mathscr{H}$ imposed by the condition $0 \le \Theta_Y(h_t) + \Lambda_Y(h_t) \le 1$.

*Definition 2.4 [28]:* The Linear Diophantine Fuzzy Set I over $\mathscr{H}$ is particularized by

$$\mathrm{I} = \{(h_t, \langle \Theta_I(h_t), \Lambda_I(h_t)\rangle, \langle \gamma_I^t, \delta_I^t\rangle) : h_t \in \mathscr{H}\}$$

imposed by the conditions $0 \le \gamma_I^t + \delta_I^t \le 1$ and $0 \le \gamma_I^t\Theta_I(h_t) + \delta_I^t\Lambda_I(h_t) \le 1$, where $\Theta_I(h_t)$, $\Lambda_I(h_t)$, $\gamma_I^t$, $\delta_I^t \in [0, 1]$ constitute respectively the grade of membership, non-membership and reference parameters of $h_t \in \mathscr{H}$.

*Definition 2.5 [20]:* The Complex Linear Diophantine Fuzzy Set J over $\mathscr{H}$ is particularized as

$$\mathrm{J} = \{(h_t, \langle \Theta_J(h_t)e^{i2\pi(w_{\Theta_J}(h_t))}, \Lambda_J(h_t)e^{i2\pi(w_{\Lambda_J}(h_t))}\rangle, \langle \gamma_J^t e^{i2\pi(w_{\gamma_J^t})}, \delta_J^t e^{i2\pi(w_{\delta_J^t})}\rangle) : h_t \in \mathscr{H}\}$$

imposed by the conditions $0 \le \gamma_J^t + \delta_J^t \le 1$, $0 \le \gamma_J^t\Theta_J(h_t) + \delta_J^t\Lambda_J(h_t) \le 1$ and $0 \le w_{\gamma_J^t} + w_{\delta_J^t} \le 1$, $0 \le w_{\gamma_J^t}w_{\Theta_J}(h_t) + w_{\delta_J^t}w_{\Lambda_J}(h_t) \le 1$, where $\Theta_J(h_t)e^{i2\pi(w_{\Theta_J}(h_t))}$, $\Lambda_J(h_t)e^{i2\pi(w_{\Lambda_J}(h_t))}$, $\gamma_J^t e^{i2\pi(w_{\gamma_J^t})}$, $\delta_J^t e^{i2\pi(w_{\delta_J^t})}$ indicates the grade of complex-valued membership, complex-valued non-membership and complex-valued reference parameters of $h_t \in \mathscr{H}$ respectively. The Complex Linear Diophantine Fuzzy Number($\mathscr{CLDFN}$) is written as

$$\mathrm{J} = (\langle(\Theta_I, w_{\Theta_I}), (\Lambda_I, w_{\Lambda_I})\rangle, \langle(\gamma_I, w_{\gamma_I}), (\delta_I, w_{\delta_I})\rangle)$$

*Definition 2.6 [21]:* The Intuitionistic Fuzzy Soft set($\mathscr{IFSS}$) particularized on $\mathscr{H}$ by

$$\langle \mathscr{Z}, \mathscr{S}\rangle = \{\langle s, \mathscr{Z}(s)\rangle / s \in \mathscr{S}, \mathscr{Z}(s) \in \mathscr{IFS}(\mathscr{H})\}$$
$$(i.e.), \mathscr{Z}(s) = \{(h_t, \langle \Theta_{\mathscr{Z}(s)}(h_t)e^{i2\pi(w_{\Theta_{\mathscr{Z}(s)}}(h_t))}, \Lambda_{\mathscr{Z}(s)}(h_t)e^{i2\pi(w_{\Lambda_{\mathscr{Z}(s)}}(h_t))}\rangle) : h_t \in \mathscr{H}\}.$$

where $\mathscr{Z} : \mathscr{S} \to \mathscr{IFS}(\mathscr{H})$ such that $\mathscr{Z}(s) = \emptyset$ if s $\notin \mathscr{S}$ and $\mathscr{IFS}(\mathscr{H})$ indicate the combination of all intuitionistic fuzzy subsets of $\mathscr{H}$.

*Definition 2.7 [20]:* Let $\mathrm{I} = (\langle(\Theta_I, w_{\Theta_I}), (\Lambda_I, w_{\Lambda_I})\rangle, \langle(\gamma_I, w_{\gamma_I}), (\delta_I, w_{\delta_I})\rangle)$ be a $\mathscr{CLDFN}$.

Then

$$Acr(I) = \frac{1}{4}[\frac{(\Theta_I + \Lambda_I)}{2} + \frac{(w_{\Theta_I} + w_{\Lambda_I})}{2} + (\gamma_I + \delta_I) + (w_{\gamma_I} + w_{\delta_I})]$$

where Acr(I) is termed as the Accuracy function of I and Acr(I) $\in [0, 1]$.

## III. COMPLEX LINEAR DIOPHANTINE FUZZY SOFT SET

This sections puts emphasis on the development of the Complex Linear Diophantine Fuzzy Soft set and is instigated as a hybrid of Complex Linear Diophantine Fuzzy set and Soft set. This structure development if coupled with the development of fundamental operations that are then used for the development of the decision making algorithm used for the analysis of the selection of optimal drone problem in the next section.

*Definition 3.1:* Let $\mathscr{H} = \{h_1, h_2, \ldots, h_m\}$ be the universal set and $\mathscr{CLDFSU}(\mathscr{H})$ be the combination of all Complex Linear Diophantine Fuzzy subsets of $\mathscr{H}$. A Complex Linear Diophantine Fuzzy Soft set ($\mathscr{CLDFSS}$) is particularized as

$$\langle Z, \mathscr{S}\rangle = \{\langle s, Z(s)\rangle / s \in \mathscr{S}, Z(s) \in \mathscr{CLDFSU}(\mathscr{H})\}$$
$$(i.e.), Z(s) = \{(h_t, \langle \Theta_{Z(s)}(h_t)e^{i2\pi(w_{\Theta_{Z(s)}}(h_t))}, \Lambda_{Z(s)}(h_t)e^{i2\pi(w_{\Lambda_{Z(s)}}(h_t))}\rangle, \langle \gamma_{Z(s)}^t e^{i2\pi(w_{\gamma_{Z(s)}^t})}, \delta_{Z(s)}^t e^{i2\pi(w_{\delta_{Z(s)}^t})}\rangle) : h_t \in \mathscr{H}\}.$$

where $Z : \mathscr{S} \to \mathscr{CLDFSU}(\mathscr{H})$ such that $Z(s) = \emptyset$ if s $\notin \mathscr{S}$. The Complex Linear Diophantine Fuzzy Soft Number($\mathscr{CLDFSN}$) can be written as

$$Z(s) = (\langle(\Theta_{Z(s)}, w_{\Theta_{Z(s)}}), (\Lambda_{Z(s)}, w_{\Lambda_{Z(s)}})\rangle, \langle(\gamma_{Z(s)}, w_{\gamma_{Z(s)}}), (\delta_{Z(s)}, w_{\delta_{Z(s)}})\rangle)$$

*Definition 3.2:* Let $(Z,\mathscr{S})$ and $(Y,\mathscr{S})$ be two $\mathscr{CLDFSS}$. Then the fundamental operational law $\oplus$ which is called algebraic sum is particularized as

$$\begin{aligned}(X,\mathscr{S}) &= (Z,\mathscr{S}) \oplus (Y,\mathscr{S})\\ (i.e.), X(s) &= \{(h_t, \langle(\Theta_{X(s)}(h_t), w_{\Theta_{X(s)}}(h_t),\\ &\quad (\Lambda_{X(s)}(h_t), w_{\Lambda_{X(s)}}(h_t))\rangle,\\ &\quad \langle(\gamma^t_{X(s)}, w_{\gamma^t_{X(s)}}), (\delta^t_{X(s)}, w_{\delta^t_{X(s)}})\rangle) : h_t \in \mathscr{H}\}.\end{aligned}$$

where

$$\left\{\begin{array}{c}\Theta_{X(s)}(h_t) = \Theta_{Z(s)}(h_t) + \Theta_{Y(s)}(h_t) - \\ \Theta_{Z(s)}(h_t)\Theta_{Y(s)}(h_t)\\ w_{\Theta_{X(s)}}(h_t) = w_{\Theta_{Z(s)}}(h_t) + w_{\Theta_{Y(s)}}(h_t) - \\ w_{\Theta_{Z(s)}}(h_t) w_{\Theta_{Y(s)}}(h_t)\\ \Lambda_{X(s)}(h_t) = \Lambda_{Z(s)}(h_t)\Lambda_{Y(s)}(h_t)\\ w_{\Lambda_{X(s)}}(h_t) = w_{\Lambda_{Z(s)}}(h_t) w_{\Lambda_{Y(s)}}(h_t)\\ \gamma^t_{X(s)} = \gamma^t_{Z(s)} + \gamma^t_{Y(s)} - \gamma^t_{Z(s)}\gamma^t_{Y(s)}\\ w_{\gamma^t_{X(s)}} = w_{\gamma^t_{Z(s)}} + w_{\gamma^t_{Y(s)}} - w_{\gamma^t_{Z(s)}} w_{\gamma^t_{Y(s)}}\\ \delta^t_{X(s)} = \delta^t_{Z(s)}\delta^t_{Y(s)}\\ w_{\delta^t_{X(s)}} = w_{\delta^t_{Z(s)}} w_{\delta^t_{Y(s)}}\end{array}\right\}_{\{t=1,2,\ldots,m\}}$$

*Definition 3.3:* The operational law $\otimes$ which is called as algebraic product between two $\mathscr{CLDFSS}$ $(Z,\mathscr{S})$ and $(Y,\mathscr{S})$ is interpreted as

$$\begin{aligned}((W,\mathscr{S})) &= (Z,\mathscr{S}) \otimes (Y,\mathscr{S})\\ (i.e.), W(s) &= \{(h_t, \langle(\Theta_{W(s)}(h_t), w_{\Theta_{W(s)}}(h_t),\\ &\quad (\Lambda_{W(s)}(h_t), w_{\Lambda_{W(s)}}(h_t))\rangle,\\ &\quad \langle(\gamma^t_{W(s)}, w_{\gamma^t_{W(s)}}), (\delta^t_{W(s)}, w_{\delta^t_{W(s)}})\rangle) : h_t \in \mathscr{H}\}.\end{aligned}$$

where

$$\left\{\begin{array}{c}\Theta_{W(s)}(h_t) = \Theta_{Z(s)}(h_t)\Theta_{Y(s)}(h_t)\\ w_{\Theta_{W(s)}}(h_t) = w_{\Theta_{Z(s)}}(h_t) w_{\Theta_{Y(s)}}(h_t)\\ \Lambda_{W(s)}(h_t) = \Lambda_{Z(s)}(h_t) + \Lambda_{Y(s)}(h_t) - \\ \Lambda_{Z(s)}(h_t)\Lambda_{Y(s)}(h_t)\\ w_{\Lambda_{W(s)}}(h_t) = w_{\Lambda_{Z(s)}}(h_t) + w_{\Lambda_{Y(s)}}(h_t) - \\ w_{\Lambda_{Z(s)}}(h_t) w_{\Lambda_{Y(s)}}(h_t)\\ \gamma^t_{W(s)} = \gamma^t_{Z(s)}\gamma^t_{Y(s)}\\ w_{\gamma^t_{W(s)}} = w_{\gamma^t_{Z(s)}} w_{\gamma^t_{Y(s)}}\\ \delta^t_{W(s)} = \delta^t_{Z(s)} + \delta^t_{Y(s)} - \delta^t_{Z(s)}\delta^t_{Y(s)}\\ w_{\delta^t_{W(s)}} = w_{\delta^t_{Z(s)}} + w_{\delta^t_{Y(s)}} - w_{\delta^t_{Z(s)}} w_{\delta^t_{Y(s)}}\end{array}\right\}_{\{t=1,2,\ldots,m\}}$$

*Definition 3.4:* Consider a $\mathscr{CLDFSS}$ $(Z,\mathscr{S})$, we define $\lambda(Z,\mathscr{S})$

$$\begin{aligned}(U,\mathscr{S}) &= \lambda(Z,\mathscr{S})\\ (i.e.), U(s) &= \{(h_t, \langle(\Theta_{U(s)}(h_t), w_{\Theta_{U(s)}}(h_t),\\ &\quad (\Lambda_{U(s)}(h_t), w_{\Lambda_{U(s)}}(h_t))\rangle,\\ &\quad \langle(\gamma^t_{U(s)}, w_{\gamma^t_{U(s)}}), (\delta^t_{U(s)}, w_{\delta^t_{U(s)}})\rangle) : h_t \in \mathscr{H}\}.\end{aligned}$$

where

$$\left\{\begin{array}{c}\Theta_{U(s)}(h_t) = 1-(1-\Theta_{Z(s)}(h_t))^\lambda\\ w_{\Theta_{U(s)}}(h_t) = 1-(1-w_{\Theta_{Z(s)}}(h_t))^\lambda\\ \Lambda_{U(s)}(h_t) = (\Lambda_{Z(s)}(h_t))^\lambda\\ w_{\Lambda_{U(s)}}(h_t) = (w_{\Lambda_{Z(s)}}(h_t))^\lambda\\ \gamma^t_{U(s)} = 1-(1-\gamma^t_{Z(s)})^\lambda\\ w_{\gamma^t_{U(s)}} = 1-(1-w_{\gamma^t_{Z(s)}})^\lambda\\ \delta^t_{U(s)} = (\delta^t_{Z(s)})^\lambda\\ w_{\delta^t_{U(s)}} = (w_{\delta^t_{Z(s)}})^\lambda\end{array}\right\}_{\{t=1,2,\ldots,m\}}$$

where $\lambda > 0$ and $\lambda$ be real.

*Definition 3.5:* Consider a $\mathscr{CLDFSS}$ $(Z,\mathscr{S})$, we define $(Z,\mathscr{S})^\lambda$

$$\begin{aligned}(P,\mathscr{S}) &= (Z,\mathscr{S})^\lambda\\ (i.e.), P(s) &= \{(h_t, \langle(\Theta_{Z(s)}(h_t), w_{\Theta_{Z(s)}}(h_t),\\ &\quad (\Lambda_{Z(s)}(h_t), w_{\Lambda_{Z(s)}}(h_t))\rangle,\\ &\quad \langle(\gamma^t_{Z(s)}, w_{\gamma^t_{Z(s)}}), (\delta^t_{Z(s)}, w_{\delta^t_{Z(s)}})\rangle) : h_t \in \mathscr{H}\}.\end{aligned}$$

where

$$\left\{\begin{array}{c}\Theta_{P(s)}(h_t) = (\Theta_{Z(s)}(h_t))^\lambda\\ w_{\Theta_{P(s)}}(h_t) = (w_{\Theta_{Z(s)}}(h_t))^\lambda\\ \Lambda_{P(s)}(h_t) = 1-(1-\Lambda_{Z(s)}(h_t))^\lambda\\ w_{\Lambda_{P(s)}}(h_t) = 1-(1-w_{\Lambda_{Z(s)}}(h_t))^\lambda\\ \gamma^t_{P(s)} = (\gamma^t_{Z(s)})^\lambda\\ w_{\gamma^t_{P(s)}} = (w_{\gamma^t_{Z(s)}})^\lambda\\ \delta^t_{P(s)} = 1-(1-\delta^t_{Z(s)})^\lambda\\ w_{\delta^t_{P(s)}} = 1-(1-w_{\delta^t_{Z(s)}})^\lambda\end{array}\right\}_{\{t=1,2,\ldots,m\}}$$

where $\lambda > 0$ and $\lambda$ be real.

*Example 3.6:*

$$\begin{aligned}Consider\ \ (Z,\mathscr{S}) = \{Z(s_1) = \{&h_1, \langle(0.7,0.7),(0.2,0.3)\rangle,\\ &\langle(0.6,0.7),(0.2,0.2)\rangle\\ &h_2, \langle(0.8,0.8),(0.1,0.1)\rangle,\\ &\langle(0.7,0.6),(0.2,0.3)\rangle\}\\ Z(s_2) = \{&h_1, \langle(0.6,0.7),(0.3,0.2)\rangle,\\ &\langle(0.7,0.7),(0.2,0.2)\rangle\\ &h_2, \langle(0.8,0.7),(0.1,0.1)\rangle,\\ &\langle(0.7,0.6),(0.2,0.3)\rangle\}\}\end{aligned}$$

and

$$\begin{aligned}Consider\ \ (Y,\mathscr{S}) = \{Y(s_1) = \{&h_1, \langle(0.9,0.8),(0.1,0.2)\rangle,\\ &\langle(0.9,0.8),(0.1,0.1)\rangle\\ &h_2, \langle(0.5,0.6),(0.4,0.3)\rangle\\ &, \langle(0.6,0.7),(0.2,0.2)\rangle\}\\ Y(s_2) = \{&h_1, \langle(0.6,0.7),(0.2,0.2)\rangle,\\ &\langle(0.6,0.7),(0.2,0.1)\rangle\\ &h_2, \langle(0.7,0.8),(0.2,0.1)\rangle,\\ &\langle(0.6,0.8),(0.2,0.1)\rangle\}\}\end{aligned}$$

and also $\lambda = 3$. Thus, we have

1) $(Z,\mathscr{S})\oplus(Y,\mathscr{S})$

$$= \{s_1, \{h_1, \langle(0.97, 0.94), (0.02, 0.06)\rangle, \langle(0.96, 0.94), (0.02, 0.02)\rangle \; h_2, \langle(0.9, 0.92), (0.04, 0.03)\rangle, \langle(0.88, 0.88), (0.04, 0.06)\rangle\} \; \{s_2 = \{h_1, \langle(0.84, 0.91), (0.06, 0.04)\rangle, \langle(0.88, 0.91), (0.04, 0.02)\rangle \; h_2, \langle(0.94, 0.94), (0.02, 0.01)\rangle, \langle(0.88, 0.92), (0.04, 0.03)\rangle\}\}$$

2) $(Z,\mathscr{S})\otimes(Y,\mathscr{S})$

$$= \{s_1, \{h_1, \langle(0.63, 0.56), (0.28, 0.44)\rangle, \langle(0.54, 0.56), (0.28, 0.28)\rangle \; h_2, \langle(0.40, 0.48), (0.46, 0.37)\rangle, \langle(0.42, 0.42), (0.36, 0.44)\rangle\} \; \{s_2 = \{h_1, \langle(0.36, 0.49), (0.44, 0.36)\rangle, \langle(0.42, 0.49), (0.36, 0.28)\rangle \; h_2, \langle(0.56, 0.56), (0.28, 0.19)\rangle, \langle(0.42, 0.48), (0.36, 0.37)\rangle\}\}$$

3) $\lambda(Z,\mathscr{S})$

$$= \{s_1, \{h_1, \langle(0.973, 0.973), (0.008, 0.027)\rangle, \langle(0.936, 0.973), (0.008, 0.008)\rangle \; h_2, \langle(0.992, 0.992), (0.001, 0.001)\rangle, \langle(0.973, 0.936), (0.008, 0.027)\rangle\} \; \{s_2 = \{h_1, \langle(0.936, 0.973), (0.027, 0.008)\rangle, \langle(0.973, 0.973), (0.008, 0.008)\rangle \; h_2, \langle(0.992, 0.973), (0.001, 0.001)\rangle, \langle(0.973, 0.936), (0.008, 0.027)\rangle\}\}$$

4) $(Z,\mathscr{S})^\lambda$

$$= \{s_1, \{h_1, \langle(0.343, 0.343), (0.488, 0.657)\rangle, \langle(0.216, 0.343), (0.488, 0.488)\rangle \; h_2, \langle(0.512, 0.512), (0.271, 0.271)\rangle, \langle(0.343, 0.216), (0.488, 0.657)\rangle\} \; \{s_2 = \{h_1, \langle(0.216, 0.343), (0.657, 0.488)\rangle, \langle(0.343, 0.343), (0.488, 0.488)\rangle \; h_2, \langle(0.512, 0.343), (0.271, 0.271)\rangle, \langle(0.343, 0.216), (0.488, 0.657)\rangle\}\}$$

*Proposition 3.7:* If $(Z,\mathscr{S})$ and $(Y,\mathscr{S})$ are two $\mathscr{CLDFSS}$ then so $(Z,\mathscr{S})\oplus(Y,\mathscr{S})$, $(Z,\mathscr{S})\otimes(Y,\mathscr{S})$, $\lambda(Z,\mathscr{S})$ and $(Z,\mathscr{S})^\lambda$

*Proof:* Since $(Z,\mathscr{S})$ and $(Y,\mathscr{S})$ are two $\mathscr{CLDFSS}$, it satisfy the following conditions:

1) $0 \le \gamma^t_{Z(s_i)} + \delta^t_{Z(s_i)} \le 1$, $0 \le \gamma^t_{Z(s_i)}\Theta_{Z(s_i)}(h_t) + \delta^t_{Z(s_i)}\Lambda_{Z(s_i)}(h_t) \le 1$ and $0 \le w_{\gamma^t_{Z(s_i)}} + w_{\delta^t_{Z(s_i)}} \le 1$, $0 \le w_{\gamma^t_{Z(s_i)}} w_{\Theta_{Z(s_i)}}(h_t) + w_{\delta^t_{Z(s_i)}} w_{\Lambda_{Z(s_i)}}(h_t) \le 1$
2) $0 \le \gamma^t_{Y(s_i)} + \delta^t_{Y(s_i)} \le 1$, $0 \le \gamma^t_{Y(s_i)}\Theta_{Y(s_i)}(h_t) + \delta^t_{Y(s_i)}\Lambda_{Y(s_i)}(h_t) \le 1$ and $0 \le w_{\gamma^t_{Y(s_i)}} + w_{\delta^t_{Y(s_i)}} \le 1$, $0 \le w_{\gamma^t_{Y(s_i)}} w_{\Theta_{Y(s_i)}}(h_t) + w_{\delta^t_{Y(s_i)}} w_{\Lambda_{Y(s_i)}}(h_t) \le 1$ for i = 1, 2, ..., n.

Let us consider $(X,\mathscr{S}) = (Z,\mathscr{S})\oplus(Y,\mathscr{S})$ where

$$\Theta_{X(s_i)}(h_t) = \Theta_{Z(s_i)}(h_t) + \Theta_{Y(s_i)}(h_t) - \Theta_{Z(s_i)}(h_t)\Theta_{Y(s_i)}(h_t)$$
$$w_{\Theta_{X(s_i)}}(h_t) = w_{\Theta_{Z(s_i)}}(h_t) + w_{\Theta_{Y(s_i)}}(h_t) - w_{\Theta_{Z(s_i)}}(h_t)w_{\Theta_{Y(s_i)}}(h_t)$$
$$\Lambda_{X(s_i)}(h_t) = \Lambda_{Z(s_i)}(h_t)\Lambda_{Y(s_i)}(h_t)$$
$$w_{\Lambda_{X(s_i)}}(h_t) = w_{\Lambda_{Z(s_i)}}(h_t)w_{\Lambda_{Y(s_i)}}(h_t)$$
$$\gamma^t_{X(s_i)} = \gamma^t_{Z(s_i)} + \gamma^t_{Y(s_i)} - \gamma^t_{Z(s_i)}\gamma^t_{Y(s_i)}$$
$$w_{\gamma^t_{X(s_i)}} = w_{\gamma^t_{Z(s_i)}} + w_{\gamma^t_{Y(s_i)}} - w_{\gamma^t_{Z(s_i)}}w_{\gamma^t_{Y(s_i)}}$$
$$\delta^t_{X(s_i)} = \delta^t_{Z(s_i)}\delta^t_{Y(s_i)}$$
$$w_{\delta^t_{X(s_i)}} = w_{\delta^t_{Z(s_i)}}w_{\delta^t_{Y(s_i)}}$$

we have $0 \le \gamma^t_{Z(s_i)} \le 1-\delta^t_{Z(s_i)}$ and $0 \le \gamma^t_{Y(s_i)} \le 1-\delta^t_{Y(s_i)}$, since $0 \le \gamma^t_{Z(s_i)} + \delta^t_{Z(s_i)} \le 1$ and $0 \le \gamma^t_{Y(s_i)} + \delta^t_{Y(s_i)} \le 1$ respectively for i = 1, 2, ..., n.

Thus, we have

$$\begin{aligned}
&\gamma^t_{X(s_i)} + \delta^t_{X(s_i)}\\
&= \gamma^t_{Z(s_i)} + \gamma^t_{Y(s_i)} - \gamma^t_{Z(s_i)}\gamma^t_{Y(s_i)} + \delta^t_{Z(s_i)}\delta^t_{Y(s_i)}\\
&\le 1 - \delta^t_{Z(s_i)} + 1 - \delta^t_{Y(s_i)} - (1-\delta^t_{Z(s_i)})(1-\delta^t_{Y(s_i)})\\
&\quad + \delta^t_{Z(s_i)}\delta^t_{Y(s_i)}\\
&= 1 - \delta^t_{Z(s_i)} + 1 - \delta^t_{Y(s_i)} - 1 + \delta^t_{Z(s_i)} + \delta^t_{Y(s_i)} - \delta^t_{Z(s_i)}\delta^t_{Y(s_i)}\\
&\quad + \delta^t_{Z(s_i)}\delta^t_{Y(s_i)}\\
&= 1
\end{aligned}$$

Also, we have $\gamma^t_{X(s_i)} + \delta^t_{X(s_i)} \ge 0$, since $\gamma^t_{Z(s_i)} + \gamma^t_{Y(s_i)} \ge \gamma^t_{Z(s_i)}\gamma^t_{Y(s_i)}$ for $\gamma^t_{Z(s_i)}, \gamma^t_{Y(s_i)} \in [0,1] \Rightarrow 0 \le \gamma^t_{X(s_i)} + \delta^t_{X(s_i)} \le 1$.

On the other hand, we have $0 \le \Theta_{X(s_i)}(h_t) \le 1$ and $0 \le \Lambda_{X(s_i)}(h_t) \le 1$ for $\Theta_{Z(s_i)}(h_t)$, $\Lambda_{Z(s_i)}(h_t)$, $\Theta_{Y(s_i)}(h_t)$, $\Lambda_{Y(s_i)}(h_t) \in [0,1]$. Therefore, we get $0 \le \gamma^t_{X(s_i)}\Theta_{X(s_i)}(h_t) + \delta^t_{X(s_i)}\Lambda_{X(s_i)}(h_t) \le 1$. In addition to that we can illustrate $\le w_{\gamma^t_{X(s_i)}} w_{\Theta_{X(s_i)}}(h_t) + w_{\delta^t_{X(s_i)}} w_{\Lambda_{X(s_i)}}(h_t) \le 1$.

$$\Rightarrow (Z,\mathscr{S})\oplus(Y,\mathscr{S}) is also a \mathscr{CLDFSS}.$$

Similarly, it can be proved that $(Z,\mathscr{S})\otimes(Y,\mathscr{S})$, $\lambda(Z,\mathscr{S})$ and $(Z,\mathscr{S})^\lambda$ are also $\mathscr{CLDFSS}$.

*Proposition 3.8:* Let us consider three $\mathscr{CLDFSS}$ as $(Z,\mathscr{S})$, $(Y,\mathscr{S})$ and $(M,\mathscr{S})$. Then the following properties holds.

1) $(Z,\mathscr{S})\oplus(Y,\mathscr{S}) = (Y,\mathscr{S})\oplus(Z,\mathscr{S})$ (commutative under $\oplus$)
2) $(Z,\mathscr{S})\otimes(Y,\mathscr{S}) = (Y,\mathscr{S})\otimes(Z,\mathscr{S})$ (commutative under $\otimes$)
3) $((Z,\mathscr{S})\oplus(Y,\mathscr{S}))\oplus(M,\mathscr{S}) = (Z,\mathscr{S})\oplus((Y,\mathscr{S})\oplus(M,\mathscr{S}))$ (associative under $\oplus$)
4) $((Z,\mathscr{S})\otimes(Y,\mathscr{S}))\otimes(M,\mathscr{S}) = (Z,\mathscr{S})\otimes((Y,\mathscr{S})\otimes(M,\mathscr{S}))$ (associative under $\otimes$)

*Proof:* The proof is evident from the above argument.

*Theorem 3.9:* 1) The finite algebraic sum of $\mathscr{CLDFSS}$ is also a $\mathscr{CLDFSS}$.

2) The finite algebraic product of $\mathscr{CLDFSS}$ is also a $\mathscr{CLDFSS}$.

*Proof:* The proof is evident from the above argument.

*Definition 3.10:* Let $\mathscr{H} = \{h_1, h_2, \ldots, h_m\}$ be the set of alternatives and $\mathscr{S} = \{s_1, s_2, \ldots, s_n\}$ denote the parameter set for decision making problem. The Complex Linear Diophantine Fuzzy Soft Decision Matrix($\mathscr{CLDFSM}_{m\times n}$) is given as:

$$[K] = [\langle(\Theta^K_{s_{ti}}, w^K_{\Theta_{s_{ti}}}), (\Lambda^K_{s_{ti}}, w^K_{\Lambda_{s_{ti}}})\rangle),$$
$$\langle(\gamma^K_{s_{ti}}, w^K_{\gamma_{s_{ti}}}), (\delta^K_{s_{ti}}, w^K_{\delta_{s_{ti}}})\rangle]_{m\times n}$$
$$= \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{pmatrix}$$

where $a_{ti} = (\langle(\Theta_{s_i}(h_t), w_{\Theta_{s_i}}(h_t)), (\Lambda_{s_i}(h_t), w_{\Lambda_{s_i}}(h_t))\rangle, \langle(\gamma_{s_{ti}}, w_{\gamma_{s_{ti}}}), (\delta_{s_{ti}}, w_{\delta_{s_{ti}}})\rangle)$, t = 1, 2, ..., m and i = 1, 2, ..., n.

*Definition 3.11:* The Accuracy matrix for $\mathscr{CLDFSM}_{m\times n}$ K is as follows:

$$A(K) = \frac{1}{4}(\frac{(\Theta^K_{s_{ti}} + \Lambda^K_{s_{ti}})}{2} + \frac{(w^K_{\Theta_{s_{ti}}} + w^K_{\Lambda_{s_{ti}}})}{2}$$
$$+ (\gamma^K_{s_{ti}} + \delta^K_{s_{ti}}) + (w^K_{\gamma_{s_{ti}}} + w^K_{\delta_{s_{ti}}})),$$
$$\forall \text{ t} = 1, 2, \ldots, \text{m and } i = 1, 2, \ldots, \text{n}.$$

## IV. $\mathscr{CLDFSS}$-DECISION MAKING TECHNIQUE

Humans are encountered with decision making problems on multiple occasions on a daily basis. In order for optimal processing of the available information, numerous decision making studies are reported in literature that incorporate fuzzy hybrid structures for diverse decision-making applications like disease diagnosis [37], [38], supply chain management [39], environmental and policy design problems [36]. The proposed structure has significant applications in addressing multi-criteria decision making problems.

### A. APPLICATION OF $\mathscr{CLDFSS}$ IN DECISION-MAKING

India, an agricultural nation, bestows a significant part of its economy on the art of cultivation. It is a primary income source for rural parts of the country. The country's economic growth is in the hands of the farmer in rural areas and the profession of most of the population. In order to optimize the farming process, farmers are moving towards implementing the art of precision agriculture where advanced technologies and IoT are used for generating improved yields and improving cost efficiency. One of the areas where high costs can be saved is the efficient spraying of fertilizers and pesticides. Conventional ways of fertilizing by hand are time-consuming and highly inefficient in terms of uniformity and consistency when spraying. Inadequate or excess spraying of fertilizers leads to failure in crop production.

In order to address this particular issue, agri-drones have gained significant attention over the last decade as the technology has improved alongside drops in their high price. A drone doesn't intensify the overall performance, but it uplifts the farmers to sort out the barriers and offers plenty of benefits. In particular, drones spraying fertilizers play a major role in crop production.

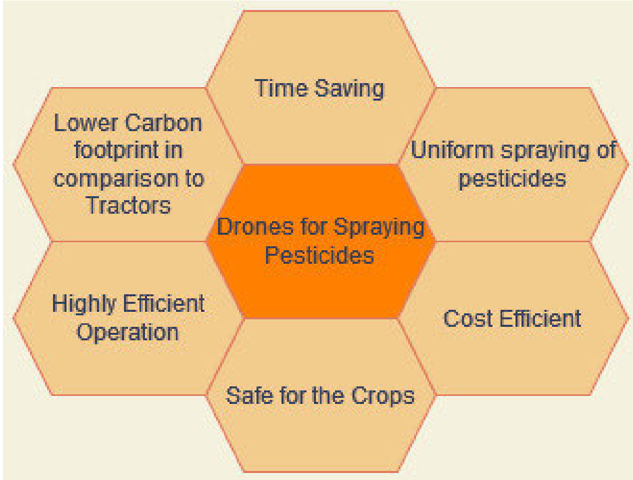


**FIGURE 1.** Advantages of use of drones for pesticide spray operations.

The benefits of drones for spraying fertilizers in agriculture include:

1) A lot of time can be saved by utilizing drones for spraying fertilizers and pesticides compared to conventional means.
2) The cost of fertilizer spraying can be reduced by using aerial technology.
3) The method of using drones for spraying is safer for crops and allows for uniform spraying of fertilizers and pesticides throughout the field.
4) Helps in fighting climatic change because most drones use electricity as compared to fossil fuels for farming vehicles.

The schematic diagram is given in Figure 1.

The main aim of this paper is to select a suitable model of drone used for spraying together with its manufacturing date.

Here, we present an algorithm for $\mathscr{CLDFSS}$ in selecting a suitable drone for spraying.

Step 1: Input the $\mathscr{CLDFSS}$ tabular representation.

Step 2: To every parameter input the priority value stated by the customer such that the sum of the priority value for every parameter must equals one.

Step 3: Compute the priority table for $\mathscr{MG}$, $\mathscr{NMG}$, Reference Parameter corresponding to Membership Grade($\mathscr{RPMG}$) and Reference Parameter corresponding to Non-Membership Grade($\mathscr{RPNMG}$) by multiplying the priority value with the corrresponding parameter value.

Step 4: In all the priority table, calculate the row-sum for every row.

Step 5: Establish the respective comparision table by fitting the data as difference of each row-sum in the priority table from with those of all other rows.

**TABLE 1.** Table value of $\mathscr{CLDFSS}$.

| $\mathscr{H}$ | $s_1$ | | | | $s_2$ | | | | $s_3$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $h_1$ | (0.5,0.7) | (0.4,0.3) | (0.6,0.7) | (0.3,0.2) | (0.6,0.8) | (0.3,0.2) | (0.7,0.8) | (0.2,0.1) | (0.7,0.9) | (0.2,0.1) | (0.8,0.7) | (0.1,0.2) |
| $h_2$ | (0.6,0.7) | (0.3,0.3) | (0.6,0.7) | (0.3,0.1) | (0.7,0.8) | (0.2,0.2) | (0.7,0.8) | (0.2,0.1) | (0.7,0.8) | (0.3,0.2) | (0.8,0.8) | (0.1,0.1) |
| $h_3$ | (0.8,0.7) | (0.1,0.1) | (0.8,0.8) | (0.1,0.2) | (0.9,0.8) | (0.1,0.1) | (0.9,0.8) | (0.1,0.1) | (0.8,0.8) | (0.2,0.1) | (0.9,0.9) | (0.1,0.1) |
| $h_4$ | (0.9,0.7) | (0.1,0.2) | (0.9,0.8) | (0.1,0.1) | (0.9,0.7) | (0.1,0.1) | (0.9,0.8) | (0.1,0.2) | (0.8,0.7) | (0.1,0.3) | (0.8,0.8) | (0.2,0.1) |

Step 6: To find the $\mathscr{MG}$, $\mathscr{NMG}$, $\mathscr{RPMG}$ and $\mathscr{RPNMG}$ for decision table, calculate the row-sum for each row in comparison table.

Step 7: Calculate the decision table by using the row-sum values of comparison table in the formula, as shown in the equation at the bottom of the next page.

Step 8: Choose a suitable alternative having maximum score.

The flowchart diagram of the above algorithm is given in Figure 2.

In this paper, Let $\{h_1, h_2, h_3, h_4\}$ be the model of drones for spraying and let $\{s_1, s_2, s_3\}$ denote the parameter set where $s_1$ = Tank size, $s_2$ = Nozzles, $s_3$ = Cost. The decisions were made by the experienced team members.

The categorization of parameters is given as follows.

1) The parameter "Tank size" signifies that the alternative is "big" or "small".
2) The parameter "Nozzles" signifies that the alternative is "many" or "less".
3) The parameter "Cost" signifies that the alternative is "cheap" or "not cheap".

The tabular characterization is given below.

| Attributes | Characteristics of $\mathscr{CLDFSS}$ |
|---|---|
| "Tank size" | $(\langle \mathscr{CVMG}, \mathscr{CVNMG}\rangle, \langle big, small\rangle)$ |
| "Nozzles" | $(\langle \mathscr{CVMG}, \mathscr{CVNMG}\rangle, \langle many, less\rangle)$ |
| "Cost" | $(\langle \mathscr{CVMG}, \mathscr{CVNMG}\rangle, \langle cheap, notcheap\rangle)$ |

The parameter "Tank size" has a valuableness $(\langle(0.5, 0.7), (0.4, 0.3)\rangle, \langle(0.6, 0.7), (0.3, 0.2)\rangle)$. This indicates that $h_1$ has 0.5 truthfulness value, 0.4 falseness value and 0.7 truthfulness value together with the manufacturing date, 0.3 falseness value together with the manufacturing date with respect to the parameter "Tank size". The pair $\langle(0.6, 0.7), (0.3, 0.2)\rangle$ denote the reference parameter corresponding to truthfulness and falseness value, where we can apprise that $h_1$ should be 0.6 value big, 0.3 value small and 0.7 value big together with the manufacturing date, 0.2 value small together with the manufacturing date. Each and every data are executed by the same method.

## B. STEP BY STEP ALGORITHM PROCESS

Step 1: Table value of $\mathscr{CLDFSS}$ is given in Table 1.

Step 2: To every parameter input the priority value stated by the customer such that the sum of the priority value for every parameter must equals one.

The priority values for the parameters $s_1$, $s_2$ and $s_3$ are 0.3, 0.4 and 0.3 respectively.

**TABLE 2.** Priority table for $\mathscr{MG}$.

| $\mathscr{H}$ | s1 | | s2 | | s3 | | Row-sum | |
|---|---|---|---|---|---|---|---|---|
| $h_1$ | 0.15 | 0.21 | 0.24 | 0.32 | 0.21 | 0.27 | 0.60 | 0.80 |
| $h_2$ | 0.18 | 0.21 | 0.28 | 0.32 | 0.21 | 0.24 | 0.67 | 0.77 |
| $h_3$ | 0.24 | 0.21 | 0.36 | 0.32 | 0.24 | 0.24 | 0.84 | 0.77 |
| $h_4$ | 0.27 | 0.21 | 0.36 | 0.28 | 0.24 | 0.21 | 0.87 | 0.70 |

**TABLE 3.** Priority table for $\mathscr{NMG}$.

| $\mathscr{H}$ | s1 | | s2 | | s3 | | Row-sum | |
|---|---|---|---|---|---|---|---|---|
| $h_1$ | 0.12 | 0.09 | 0.12 | 0.08 | 0.06 | 0.03 | 0.30 | 0.20 |
| $h_2$ | 0.09 | 0.09 | 0.08 | 0.08 | 0.09 | 0.06 | 0.26 | 0.23 |
| $h_3$ | 0.03 | 0.03 | 0.04 | 0.04 | 0.06 | 0.03 | 0.13 | 0.10 |
| $h_4$ | 0.03 | 0.06 | 0.04 | 0.04 | 0.03 | 0.09 | 0.10 | 0.19 |

**TABLE 4.** Priority table for $\mathscr{RPMG}$.

| $\mathscr{H}$ | s1 | | s2 | | s3 | | Row-sum | |
|---|---|---|---|---|---|---|---|---|
| $h_1$ | 0.18 | 0.21 | 0.28 | 0.32 | 0.24 | 0.21 | 0.70 | 0.74 |
| $h_2$ | 0.18 | 0.21 | 0.28 | 0.32 | 0.24 | 0.24 | 0.70 | 0.77 |
| $h_3$ | 0.24 | 0.24 | 0.36 | 0.32 | 0.27 | 0.27 | 0.87 | 0.83 |
| $h_4$ | 0.27 | 0.24 | 0.36 | 0.32 | 0.24 | 0.24 | 0.87 | 0.80 |

**TABLE 5.** Priority table for $\mathscr{RPNMG}$.

| $\mathscr{H}$ | s1 | | s2 | | s3 | | Row-sum | |
|---|---|---|---|---|---|---|---|---|
| $h_1$ | 0.09 | 0.06 | 0.08 | 0.04 | 0.03 | 0.06 | 0.20 | 0.16 |
| $h_2$ | 0.09 | 0.03 | 0.08 | 0.04 | 0.03 | 0.03 | 0.20 | 0.10 |
| $h_3$ | 0.03 | 0.06 | 0.04 | 0.04 | 0.03 | 0.03 | 0.10 | 0.13 |
| $h_4$ | 0.03 | 0.03 | 0.04 | 0.08 | 0.06 | 0.03 | 0.13 | 0.14 |

**TABLE 6.** Comparison table for $\mathscr{MG}$.

| | h1 | | h2 | | h3 | | h4 | | Row-sum | |
|---|---|---|---|---|---|---|---|---|---|---|
| $h_1$ | 0.0 | 0.0 | -0.07 | 0.03 | -0.24 | 0.03 | -0.27 | 0.1 | -0.58 | 0.16 |
| $h_2$ | 0.07 | -0.03 | 0.0 | 0.0 | -0.17 | 0.0 | -0.2 | 0.07 | -0.3 | 0.04 |
| $h_3$ | 0.24 | -0.03 | 0.17 | 0.0 | 0.0 | 0.0 | -0.03 | 0.07 | 0.38 | 0.04 |
| $h_4$ | 0.27 | -0.1 | 0.2 | -0.07 | 0.03 | -0.07 | 0.0 | 0.0 | 0.50 | -0.24 |

Step 3: Compute the priority table for $\mathscr{MG}$, $\mathscr{NMG}$, $\mathscr{RPMG}$ and $\mathscr{RPNMG}$ by multiplying the priority value with the corresponding parameter value. and

Step 4: In all the priority table, calculate the row-sum for every row.

It is given in Table 2, 3, 4, and 5.

Step 5: Establish the respective comparison table by fitting the data as difference of each row-sum in the priority table from with those of all other rows. and

Step 6: To find the $\mathscr{MG}$, $\mathscr{NMG}$, $\mathscr{RPMG}$ and $\mathscr{RPNMG}$ for decision table, calculate the row-sum for each row in comparison table. The data is the respective format is presented in Table 6, 7, 8, and 9.

Step 7: Calculate the decision table by using the row-sum values of comparison table using the formula, as shown in the equation at the bottom of the next page.

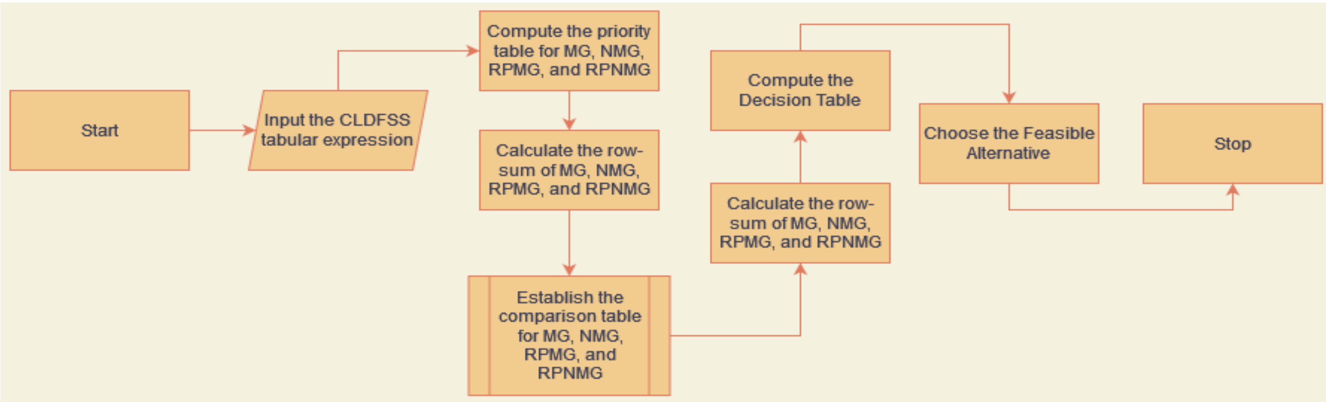


**FIGURE 2.** **Frame diagram for proposed algorithm.**

**TABLE 7.** **Comparison table for $\mathscr{NMG}$.**

| | $h_1$ | | $h_2$ | | $h_3$ | | $h_4$ | | Row-sum | |
|---|---|---|---|---|---|---|---|---|---|---|
| $h_1$ | 0.0 | 0.0 | 0.04 | -0.03 | 0.17 | 0.1 | 0.2 | 0.01 | 0.41 | 0.08 |
| $h_2$ | -0.04 | 0.03 | 0.0 | 0.0 | 0.13 | 0.13 | 0.16 | 0.04 | 0.25 | 0.20 |
| $h_3$ | -0.17 | -0.1 | -0.13 | -0.13 | 0.0 | 0.0 | 0.03 | -0.09 | -0.27 | -0.32 |
| $h_4$ | -0.2 | -0.01 | -0.16 | -0.04 | -0.03 | 0.09 | 0.0 | 0.0 | -0.39 | 0.04 |

**TABLE 8.** **Comparison table for $\mathscr{RPMG}$.**

| | $h_1$ | | $h_2$ | | $h_3$ | | $h_4$ | | Row-sum | |
|---|---|---|---|---|---|---|---|---|---|---|
| $h_1$ | 0.0 | 0.0 | 0.0 | -0.03 | -0.17 | -0.09 | -0.17 | -0.06 | -0.34 | -0.18 |
| $h_2$ | 0.0 | 0.03 | 0.0 | 0.0 | -0.17 | -0.06 | -0.17 | -0.03 | -0.34 | -0.06 |
| $h_3$ | 0.17 | 0.09 | 0.17 | 0.06 | 0.0 | 0.0 | 0.0 | 0.03 | 0.34 | 0.18 |
| $h_4$ | 0.17 | 0.06 | 0.17 | 0.03 | 0.0 | -0.03 | 0.0 | 0.0 | 0.34 | 0.06 |

**TABLE 9.** **Comparison table for $\mathscr{RPNMG}$.**

| | $h_1$ | | $h_2$ | | $h_3$ | | $h_4$ | | Row-sum | |
|---|---|---|---|---|---|---|---|---|---|---|
| $h_1$ | 0.0 | 0.0 | 0.0 | 0.06 | 0.1 | 0.03 | 0.07 | 0.02 | 0.17 | 0.11 |
| $h_2$ | 0.0 | -0.06 | 0.0 | 0.0 | 0.1 | -0.03 | 0.07 | -0.04 | 0.17 | -0.13 |
| $h_3$ | -0.1 | -0.03 | -0.1 | 0.03 | 0.0 | 0.0 | -0.03 | -0.01 | -0.23 | -0.01 |
| $h_4$ | -0.07 | -0.02 | -0.07 | 0.04 | 0.03 | 0.01 | 0.0 | 0.0 | -0.11 | 0.03 |

It is specified in Table 10

Step 8: Choose a suitable alternative having maximum score.

**TABLE 10.** **Decision table.**

| $\mathscr{H}$ | $\mathscr{MG}$ | | $\mathscr{NMG}$ | | $\mathscr{RPMG}$ | | $\mathscr{RPNMG}$ | | Score |
|---|---|---|---|---|---|---|---|---|---|
| $h_1$ | -0.58 | 0.16 | 0.41 | 0.08 | -0.34 | -0.18 | 0.17 | 0.11 | 1.145 |
| $h_2$ | -0.30 | 0.04 | 0.25 | 0.2 | -0.34 | -0.06 | 0.17 | -0.13 | 1.425 |
| $h_3$ | 0.38 | 0.04 | -0.27 | -0.32 | 0.34 | 0.18 | -0.23 | -0.01 | 2.885 |
| $h_4$ | 0.50 | -0.24 | -0.39 | 0.04 | 0.34 | 0.06 | -0.11 | 0.03 | 2.545 |

After the computation of data, the last and final step is the selection of the suitable alternative out of the available options. For this problem, the alternative $h_3$ is the most suitable drone for spraying of fertilizer and pesticides in agriculture.

## V. COMPARATIVE EXPLORATION

The comparison of the proposed conception with the other existing is presented to examine the proposed conception's generality and sustainability which was reflected in Table 11.

1) More after, many real-life applications do not have precisely defined the stand of membership. To prevail over these circumstances, the notion of $\mathscr{FS}$ [35] was developed, which deals with the values in [0, 1]. But it could not deal with the situations involving $\mathscr{NMG}$,

$$Score = \frac{Amplitude\ term\ of\ \mathscr{MG} - Amplitude\ term\ of\ \mathscr{NMG} + 1}{2} + \frac{Phase\ term\ of\ \mathscr{MG} - Phase\ term\ of\ \mathscr{NMG} + 1}{2} + \frac{Amplitude\ term\ of\ \mathscr{RPMG} - Amplitude\ term\ of\ \mathscr{RPNMG} + 1}{2} + \frac{Phase\ term\ of\ \mathscr{RPMG} - Phase\ term\ of\ \mathscr{RPNMG} + 1}{2}$$


$$Score = \frac{Amplitude\ term\ of\ \mathscr{MG} - Amplitude\ term\ of\ \mathscr{NMG} + 1}{2} + \frac{Phase\ term\ of\ \mathscr{MG} - Phase\ term\ of\ \mathscr{NMG} + 1}{2} + \frac{Amplitude\ term\ of\ \mathscr{RPMG} - Amplitude\ term\ of\ \mathscr{RPNMG} + 1}{2} + \frac{Phase\ term\ of\ \mathscr{RPMG} - Phase\ term\ of\ \mathscr{RPNMG} + 1}{2}$$

**TABLE 11. Comparison table.**

| Conception | $\mathscr{MG}$ | $\mathscr{NMG}$ | Reference parameters | Parametrization tools | Capability to deal with 2-D information |
|---|---|---|---|---|---|
| $\mathscr{FS}$ [35] | ✓ | × | × | × | × |
| $\mathscr{SS}$ [22] | × | × | × | ✓ | × |
| $\mathscr{CFS}$ [27] | ✓ | × | × | × | ✓ |
| $\mathscr{IFS}$ [33] | ✓ | ✓ | × | × | × |
| $\mathscr{IFSS}$ [21] | ✓ | ✓ | × | ✓ | × |
| $\mathscr{CLDFS}$ [20] | ✓ | ✓ | ✓ | × | ✓ |
| $\mathscr{CLDFSS}$ (proposed) | ✓ | ✓ | ✓ | ✓ | ✓ |

reference parameters, parametrization tools, and 2D information.

2) The concept called $\mathscr{SS}$ [22] was introduced to handle the situations compelling parametrization tools. Yet it lacks to deal with the information involving $\mathscr{MG}$, $\mathscr{NMG}$, reference parameter, and 2D information.
3) The perception of ($\mathscr{CFS}$) [27] was initiated mainly to operate the environment which includes 2D information. Nevertheless, it is a deficit to approach problems involving $\mathscr{NMG}$, reference parameters, and parametrization tools.
4) The concept called $\mathscr{IFS}$ [33] failed to deal with the locality, which includes reference parameters, parametrization tools, and 2D information. However, it handles situation involving $\mathscr{MG}$ and $\mathscr{NMG}$.
5) The theory of $\mathscr{IFSS}$ [21] deficit to address environment which includes reference parameter and 2D information. Instead, it addresses with $\mathscr{MG}$, $\mathscr{NMG}$ and parametrization tools.
6) Also, the notion called $\mathscr{CLDFS}$ [20] fail to deal with the parametrization tools. However, it can cope with the situation regarding $\mathscr{MG}$, $\mathscr{NMG}$ reference parameters, and 2D information.

The limitations of the existing conception has been contented by the proposed one for the better handling of certain real life problems.

## VI. CONCLUSION

The $\mathscr{CVMG}$ and $\mathscr{CVNMG}$ can be freely selected without any restrictions is the supremacy of the concept $\mathscr{CLDFSS}$. In this work, the advancement of knowledge measure in $\mathscr{CLDFSS}$ was done. Comparative exploration exhibits that the proposed knowledge measure together with the theorems and proofs were powerful and acceptable to deal with $\mathscr{MCDM}$ problem. We have also advanced an algorithm to deal with the $\mathscr{MCDM}$ problem incorporating the proposed $\mathscr{CLDFSS}$. The algorithm was found effective because it satisfies the needs of a decision maker in the handling $\mathscr{MCDM}$ problem. In addition to that, it helps to select a suitable agri-drone for spraying fertilizers and pesticides together with its manufacturing date in agriculture which satisfies the current complication faced by the farmers. The Managerial implications followed by Future directions are given below. Significant managerial include of the concept is to develop both theoretical and practical experience based on $\mathscr{CLDFSS}$. The process of finding a suitable agri-drone for spraying fertilizers and pesticides together with its manufacturing and performance data(involving parametrization tool, reference parameters, and 2D information) by the means of the proposed algorithm is the evidence provided. Also, this technique will have a significant role in the medical field, the field of robotics, and so on. The future directions of the work include more research will be undertaken to develop a new conception called Lattice Ordered Complex Linear Diophantine Fuzzy Soft set($\mathscr{LOCLDFSS}$)(where the order exists between the set of parameters based on the preference) together with its properties and theorems. Extension of the presented concept to matrices, distance and entropy measure, similarity measure, TOPSIS method, VIKOR method, Operators of $\mathscr{LOCLDFSS}$ will be future work. Also, real-life applications of $\mathscr{LOCLDFSS}$ in the field of robotics, medical field, forecasting, agricultural field and so on can be studied in the future.

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**VIMALA JAYAKUMAR** received the Ph.D. degree in mathematics from Alagappa University, Karaikudi, Tamil Nadu, India, in 2007. She has 19 years of teaching experience. She has presented many papers in various international conferences. She published three books. She has completed six Ph.D.'s and has five ongoing Ph.D.'s under her guidance. She has published more than 50 research articles in various reputed journals. Her research interests include algebra, lattice theory, fuzzy mathematics, algebraic hyperstructures, fuzzy algebraic hyperstructures, group theory, soft computing, neutrosophic sets, and multicriteria decision making. She was awarded the "Best Researcher Award" in mathematics 2015–2016 by International Multidisciplinary Research Foundation (IMRF) and "Distinguished Women in Science 2017" by VIWA. She has professionally visited more than five countries.

**ASHMA BANU KATHER MOHIDEEN** received the M.Sc. degree (Hons.) in mathematics from the Madras Christian College, affiliated to Madras University, Chennai, Tamil Nadu, India. She is currently a Research Scholar with Alagappa University. Her research interests include complex fuzzy systems, soft computing, fuzzy mathematics, and decision-making theory.

**MUHAMMAD HARIS SAEED** was born in Pakistan. He received the degree from the Government College Township (GCT), Lahore, Pakistan. He opted for chemistry and biology as his majors while at GCT. He is currently pursuing the M.S. degree in chemistry with the University of Management and Technology (UMT), Lahore. He is also working as a Teaching Assistant during his master's studies. He is also doing his research in computational chemistry with UMT. He has 11 research publications under his name. His research interests include applying MCDM in different aspects of chemistry, QSPR analysis, and disease diagnostic support systems.

**HAMED ALSULAMI** received the Ph.D. degree from the College of Liberal Arts and Science, Arizona State University (ASU). He has been working with the Department of Mathematics, King Abdulaziz University, since 1994, where he is currently working as a Professor. He is a very active researcher in analysis. He has published more than 200 publications in science journals.

**AFTAB HUSSAIN** received the Ph.D. degree in mathematics from International Islamic University Islamabad, Pakistan, in 2016. He is currently working as an Associate Professor with the Department of Mathematics, King Abdulaziz University, Jeddah, Saudi Arabia. He has published 80 research papers and ten research papers have been accepted in international journals. His research interest includes fixed point theory. He was awarded the Best Researcher, in 2019. He has attended various national and international conferences.

**MUHAMMAD SAEED** was born in Pakistan, in July 1970. He received the Ph.D. degree in mathematics from Quaid-i-Azam University, Islamabad, Pakistan, in 2012. He taught mathematics at intermediate and degree level with exceptional results. He worked as the Chairperson of the Department of Mathematics, UMT, Lahore, from 2014 to January 2021. Under his dynamics leadership, the Mathematics Department has produced ten Ph.D. scholars. He has supervised more than 25 M.S., six Ph.D.'s, and has published more than 100 research articles in recognized journals. His research interests include fuzzy mathematics, rough sets, soft set theory, hypersoft set, neutrosophic sets, algebraic and hybrid structures of soft sets and hypersoft sets, multicriteria decision making, optimizations, artificial intelligence, pattern recognition and optimization under convex environments, graph theory in fuzzy-like, soft-like, and hypersoft-like environments, similarity, distance measures, and their relevant operators in multipolar hybrid structures. He was awarded the "Best Teacher," in 1999, 2000, 2001, and 2002, and was involved as a Teacher Trainer for professional development for more than five years. More information can be found at: https://www.researchgate.net/profile/Muhammad_Saeed98