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# Identify the most Productive Crop to Encourage Sustainable Farming Methods in Smart Farming using Neutrosophic Environment

**Ahmed Abdelhafeez [1,*], Hadeer Mahmoud [2] and Alber S. Aziz [3]**

[1,2,3] Faculty of Information Systems and Computer Science, October 6th University, Giza, 12585, Egypt.
Emails: aahafeez.scis@o6u.edu.eg; hadeer.mhmoud.csis@o6u.edu.eg; Albershawky.csis@o6u.edu.eg.

* Correspondence: aahafeez.scis@o6u.edu.eg.

**Abstract:** Only with careful management can the data provided by crops be used to make smart, profitable choices. Data has become the central ingredient in contemporary agriculture, and the recent advancements in handling it are contributing greatly to the meteoric rise of smart farming. Gains in efficiency and longevity may be realized to a significant degree by using the objective data collected by sensors. These data-driven farms can maximize output while minimizing waste and environmental impact thanks to the information they collect and analyze. Various criteria and factors in smart farming can aid in productivity. Sensors, drones, Global Positioning System (GPS) mapping, and other technologies are used in "smart farming" to track variables such as crop development, soil quality, and weather to optimize yields. These technologies are used in smart farming to increase sustainability, decrease food waste, and maximize agricultural yields. This paper suggested a mean weighting methodology to analyze and select the best criteria in smart farming. This method is integrated with the neutrosophic set to deal with uncertain data. This paper achieved the sustainability criteria as the best criteria.

**Keywords:** Smart Farming; Sustainability; Neutrosophic Set; Productivity; Crops.

## 1. Introduction

Finding the most beneficial crop using demographic variables is a sustainable practice. Excellent for rural usage. Greenhouses and mechanized farming using precision farming techniques are at the heart of modern agriculture, which also works to preserve and improve the planet's dwindling renewable resources. Drip and sprinkler irrigation systems are an innovative way to save water. Rapid population expansion calls for greater productivity from each plot of land. Sustainable farming practices have increased in significance among needs and supply to control variability [1, 2].

Now is the time to focus on raising people's living standards and safeguarding the planet's natural resources. The financial, social, and ecological benefits of sustainable agriculture are all interconnected. Farmers' sense of competence and happiness are intimately linked to these elements. Value in the marketplace and how much money farmers make from their crops. The high temperatures and little rainfall in the dry zone make for a difficult natural environment. Food safety and economic growth are both bolstered by the farming sector [3, 4].

Natural soil nutrients, the retail value of crop output, the condition of water, and the retention of carbon are all crucial aspects of the farming industry, as stated by the Food and Agriculture Organization (FAO) [5, 6].

Farming is now much easier thanks to mechanization. Computerized platforms with sensors provide choices for farmers to track and perform agricultural tasks. Several methods that make use of machines have been suggested in the literature, and these methods make use of computer and database technology [7, 8]. However, it is more cost-effective and useful for field management. Producers need a straightforward answer right now. To address the aforementioned problems, it is proposed to implement an autonomous system consisting of a master controller and the necessary sensors. Developed with the farmer in mind. Sensors may possess a significant part in computer autonomy. To capitalize on agriculture's global advantages, the government has developed several different Internet of Things (IoT) policies [9]–[11]. This analysis has uncertain data. So, the neutrosophic set is used to compute the weights of the criteria.

The fuzzy set (FS) theory was first proposed by Zadeh (1965) to deal with gaps in understanding. To express membership and non-membership functions, Atanassov further extended the FSs theory to intuitionistic FSs. Smarandache later introduced the neutrosophic sets, which are an extension of FSs. The use of neutrosophic sets to solve difficult decision-making issues has been fruitful [12]–[14]. This study used the triangular neutrosophic number with the mean weights to compute the weights of the criteria.

## 2. Farming Management

For statistics or photos to be interpreted clearly into useful information, the raw observations of crops' important properties must be processed rapidly. Even while crop management using field data had already progressed by the time Precision Agriculture was discovered thirty years ago, the advent of the digital data age has undoubtedly had a profound effect. Field administration has always included farmers visually assessing the progress of crops to arrive at an assessment with which they make judgments and activate offering various treatments to crops. This is especially true in areas where automation has not yet arrived [15, 16].

This method is grounded on the knowledge and observations made by producers in the field. Growers who are part of a cooperative may also rely on the advice of experts and engineers employed by the organization. Field administration on farms using cutting-edge technologies differs with each phase of production [7, 17].

The crop itself serves as the foundation for this data-driven, data-driven management approach, which makes use of the crop's inherent spatial and temporal variability. The sensors are the particular components via which reliable information is gathered, and the base is the physical method by which this is accomplished. The characteristics of the crop, soil, and environment are all sources of information that may be found in the data [18, 19].

Information from the sensors may be retrieved in several different ways, for as by copying and pasting it onto a pen drive and then putting it into a USB port, or by using software programs that are synchronized with the Internet. Connecting the data and decision-making phases requires sophisticated algorithms and filtering processes to extract relevant information and guide the grower toward optimal outcomes. Actuation, or the actual carrying out of a decision system's directive, is often accomplished by high-tech machinery outfitted with a computerized control unit. The cycle begins and ends at the crop level when each operation is performed upon it; the crop's reaction is then recorded by specialized sensors, and the loop is repeated methodically until harvest. Figure 1 shows the smart farming system. The crop is the first stage, then the platform. Then the data and decision. Then apply the mean weighting method to compute the weights of criteria by the triangular neutrosophic set.

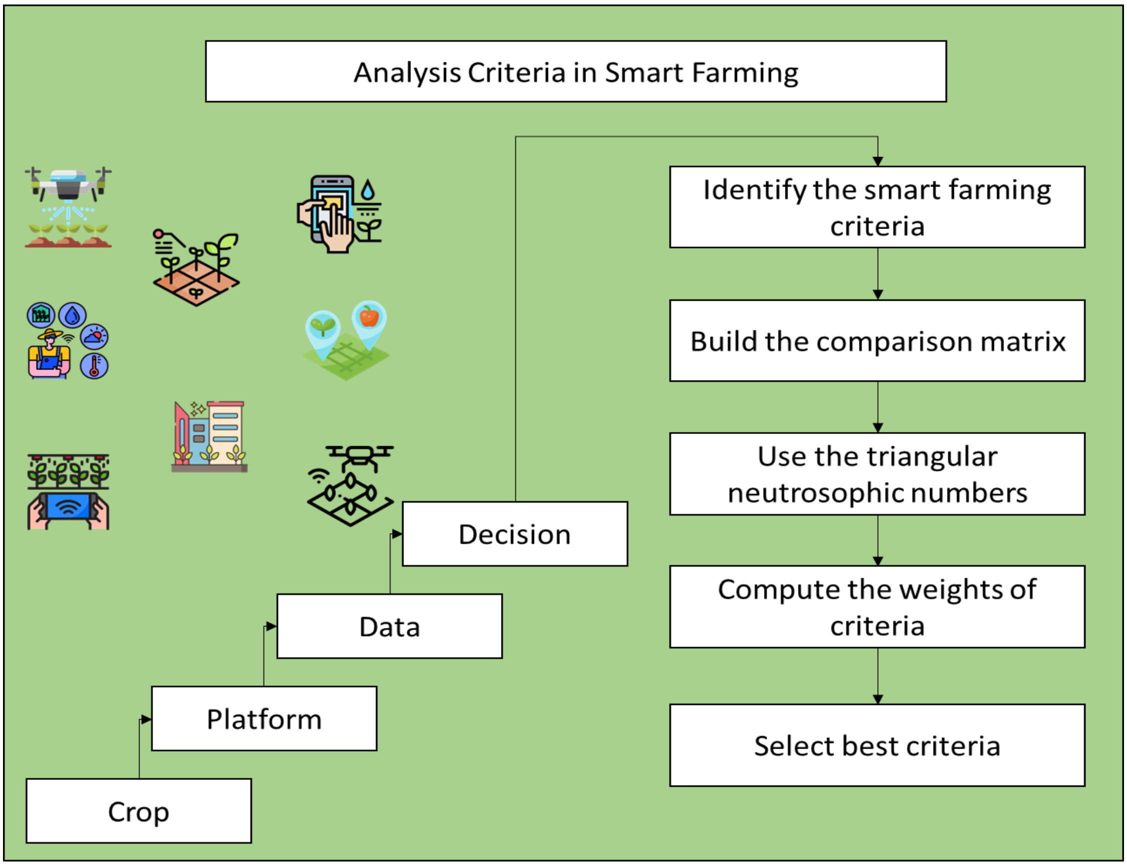


**Figure 1**. The smart farming system.

## 3. Agriculture 4.0

Agriculture 4.0, Digital Farming, and Smart Farming are all names for the same data-centric farming philosophy that emerged when sensors and data administration were added to the well-established idea of precise farming to boost operational precision. Thus, precision farming is the foundation of Agriculture 4.0, with farmers adopting data-generating technology to better inform operational and strategic choices. Farmers have always relied on field checks to inform their judgments, which are based on years of expertise [20, 21].

As certain areas have become too vast to be maintained successfully considering the triple factors that will lead to next year's efficiency, sustainability, and accessibility (for people) this technique is no longer viable. Smart farming's focus on advanced systems of administration is yielding real-world benefits. Even though some farmers have extensive field expertise, technology may give a systematic method to uncover unexpected issues that would be difficult to spot with just eye examination on infrequent visits [22, 23].

Young farmers have a more favorable attitude towards embracing contemporary equipment than their more seasoned counterparts do; this is likely because these instruments may supplement the former's limited expertise in the field [16, 24].

## 4. Neutrosophic Mean Method

When applied to real circumstances, the crisp-based, classical theory does not appear well-suited for dealing with ambiguity. In 1986, Atanassov created an intuitionistic fuzzy set (IFS), a generalization of the FS. The aforementioned sets are not without their flaws. To overcome these limitations, a new theory known as neutrosophic logic and sets was created. Neutrosophic sets are expansions of sets that are classical, fuzzy, or IFS. A neutrosophic set's membership function includes degrees of truth, falsehood, and ambiguity. In this case, indeterminacy provides more accurate results than FSs or IFS. As a result, neutrosophy will provide better results than fuzzy and IFSs [25]–[28]. We can define the triangular neutrosophic set as:

$$T(a_i) = \begin{cases} \left(\frac{a_i - x}{y - x}\right) g_x, & x \le a_i \le y \\ g_x, & a_i = y \\ \left(\frac{z - a_i}{z - y}\right) g_x, & y \le a_i \le z \\ 0, & otherwise \end{cases} \tag{1}$$

$$I(a_i) = \begin{cases} \left(\frac{y - a_i}{y - x}\right) v_x, & x \le a_i \le y \\ v_x, & a_i = y \\ \left(\frac{a_i - z}{y - x}\right) v_x, & y \le a_i \le z \\ 1, & otherwise \end{cases} \tag{2}$$

$$F(a_i) = \begin{cases} \left(\frac{y - a_i}{y - x}\right) k_x, & x \le a_i \le y \\ k_x, & a_i = y \\ \left(\frac{a_i - z}{y - x}\right) k_x, & y \le a_i \le z \\ 1, & otherwise \end{cases} \tag{3}$$

The simplest weighing method is the MW, which gives equal weight to each property.
Compute the weights of the criteria.

$$w_j = \frac{a_j}{\sum_{j=1}^{n} a_j} \tag{4}$$

## 5. Smart Farming Analysis

This section analysis the sustainability criteria to achieve productivity in smart farming. This paper collected ten criteria to analyze it.

Smart farming, also known as precision agriculture, is a kind of farming that makes use of information and communication technologies to increase productivity, decrease waste, and enhance environmental friendliness. Sensors, drones, GPS mapping, and other technologies are used in "smart farming" to track variables such as crop development, soil quality, and weather to optimize yields.

Some components of efficient farming are: Temperature, humidity, and soil moisture are just a few examples of the environmental parameters that may be measured with sensors. Robotics: Robots may be employed in agriculture to replace human labor in planting, harvesting, and pest control. Drones: Farmers may benefit from using drones to gather information on crop development, soil conditions, and other things. Precision planting and fertilization are made easier with the use of GPS maps of farms. Large volumes of data acquired by sensors and drones may be processed using data analysis techniques to provide insights into crop development and soil health.

Considerations for efficient farming include: The goal of "smart farming" should be to make agriculture more sustainable and less harmful to the environment. Efficient production: Smart farming aims to maximize crop output while decreasing waste. Value for money: Farmers should see a profit from adopting smart agricultural practices. All farmers, from hobbyists to corporate giants, should have access to cutting-edge agricultural technology. Smart farming technologies should be adaptable and simple to use, so that they may be incorporated into current agricultural systems.

The experts built the pairwise comparison between ten criteria as shown in Table 1. Then replace their opinions by using the numbers of triangular neutrosophic. Then compute the weights of criteria by the mean weighting method as shown in Figure 2.

**Table 1**. The Comparison matrix between criteria of smart farming.

| | $SFC_1$ | $SFC_2$ | $SFC_3$ | $SFC_4$ | $SFC_5$ | $SFC_6$ | $SFC_7$ | $SFC_8$ | $SFC_9$ | $SFC_{10}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $SFC_1$ | 1 | {(0,1,2); 0.30, 0.75, 0.70} | {(2,3,4); 0.90, 0.10, 0.10} | {(1,2,3); 0.80, 0.15, 0.20} | {(2,3,4); 0.90, 0.10, 0.10} | {(0,1,2); 0.30, 0.75, 0.70} | {(1,2,3); 0.80, 0.15, 0.20} | {(0,1,2); 0.30, 0.75, 0.70} | {(2,3,4); 0.90, 0.10, 0.10} | {(0,1,2); 0.30, 0.75, 0.70} |
| $SFC_2$ | {(0,1,2); 0.30, 0.75, 0.70} | 1 | {(1,2,3); 0.80, 0.15, 0.20} | {(0,1,2); 0.30, 0.75, 0.70} | {(1,2,3); 0.80, 0.15, 0.20} | {(1,2,3); 0.80, 0.15, 0.20} | {(4,4,4); 1.00, 0.00, 0.00} | {(1,2,3); 0.80, 0.15, 0.20} | {(1,2,3); 0.80, 0.15, 0.20} | {(1,2,3); 0.80, 0.15, 0.20} |
| $SFC_3$ | {(2,3,4); 0.90, 0.10, 0.10} | {(1,2,3); 0.80, 0.15, 0.20} | 1 | {(1,2,3); 0.80, 0.15, 0.20} | {(1,2,3); 0.80, 0.15, 0.20} | {(4,4,4); 1.00, 0.00, 0.00} | {(4,4,4); 1.00, 0.00, 0.00} | {(1,2,3); 0.80, 0.15, 0.20} | {(0,1,2); 0.30, 0.75, 0.70} | {(4,4,4); 1.00, 0.00, 0.00} |
| $SFC_4$ | {(1,2,3); 0.80, 0.15, 0.20} | {(0,1,2); 0.30, 0.75, 0.70} | {(1,2,3); 0.80, 0.15, 0.20} | 1 | {(4,4,4); 1.00, 0.00, 0.00} | {(2,3,4); 0.90, 0.10, 0.10} | {(1,2,3); 0.80, 0.15, 0.20} | {(0,1,2); 0.30, 0.75, 0.70} | {(1,2,3); 0.80, 0.15, 0.20} | {(2,3,4); 0.90, 0.10, 0.10} |
| $SFC_5$ | {(2,3,4); 0.90, 0.10, 0.10} | {(1,2,3); 0.80, 0.15, 0.20} | {(1,2,3); 0.80, 0.15, 0.20} | {(4,4,4); 1.00, 0.00, 0.00} | 1 | {(1,2,3); 0.80, 0.15, 0.20} | {(2,3,4); 0.90, 0.10, 0.10} | {(1,2,3); 0.80, 0.15, 0.20} | {(4,4,4); 1.00, 0.00, 0.00} | {(1,2,3); 0.80, 0.15, 0.20} |
| $SFC_6$ | {(0,1,2); 0.30, 0.75, 0.70} | {(1,2,3); 0.80, 0.15, 0.20} | {(4,4,4); 1.00, 0.00, 0.00} | {(2,3,4); 0.90, 0.10, 0.10} | {(1,2,3); 0.80, 0.15, 0.20} | 1 | {(1,2,3); 0.80, 0.15, 0.20} | {(0,1,2); 0.30, 0.75, 0.70} | {(0,1,2); 0.30, 0.75, 0.70} | {(0,1,2); 0.30, 0.75, 0.70} |
| $SFC_7$ | {(1,2,3); 0.80, 0.15, 0.20} | {(4,4,4); 1.00, 0.00, 0.00} | {(4,4,4); 1.00, 0.00, 0.00} | {(1,2,3); 0.80, 0.15, 0.20} | {(2,3,4); 0.90, 0.10, 0.10} | {(1,2,3); 0.80, 0.15, 0.20} | 1 | {(1,2,3); 0.80, 0.15, 0.20} | {(1,2,3); 0.80, 0.15, 0.20} | {(1,2,3); 0.80, 0.15, 0.20} |
| $SFC_8$ | {(0,1,2); 0.30, 0.75, 0.70} | {(1,2,3); 0.80, 0.15, 0.20} | {(1,2,3); 0.80, 0.15, 0.20} | {(0,1,2); 0.30, 0.75, 0.70} | {(1,2,3); 0.80, 0.15, 0.20} | {(0,1,2); 0.30, 0.75, 0.70} | {(1,2,3); 0.80, 0.15, 0.20} | 1 | {(1,2,3); 0.80, 0.15, 0.20} | {(1,2,3); 0.80, 0.15, 0.20} |
| $SFC_9$ | {(2,3,4); 0.90, 0.10, 0.10} | {(1,2,3); 0.80, 0.15, 0.20} | {(0,1,2); 0.30, 0.75, 0.70} | {(1,2,3); 0.80, 0.15, 0.20} | {(4,4,4); 1.00, 0.00, 0.00} | {(0,1,2); 0.30, 0.75, 0.70} | {(1,2,3); 0.80, 0.15, 0.20} | {(1,2,3); 0.80, 0.15, 0.20} | 1 | {(4,4,4); 1.00, 0.00, 0.00} |
| $SFC_{10}$ | {(0,1,2); 0.30, 0.75, 0.70} | {(1,2,3); 0.80, 0.15, 0.20} | {(4,4,4); 1.00, 0.00, 0.00} | {(2,3,4); 0.90, 0.10, 0.10} | {(1,2,3); 0.80, 0.15, 0.20} | {(0,1,2); 0.30, 0.75, 0.70} | {(1,2,3); 0.80, 0.15, 0.20} | {(1,2,3); 0.80, 0.15, 0.20} | {(4,4,4); 1.00, 0.00, 0.00} | 1 |

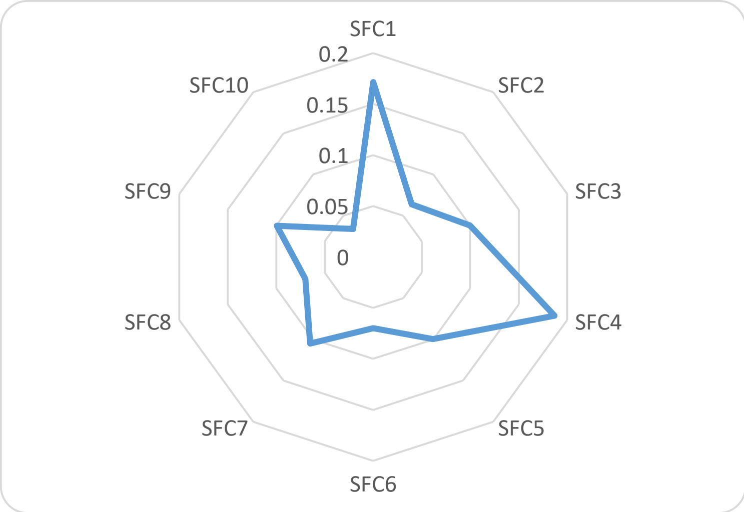


**Figure 2.** The weights of factors in smart farming.

The sustainability criterion is the best. Smart farming could lessen negative effects on the environment and boost agricultural sustainability.

## 6. Conclusion

Smart farming, also known as precision agriculture, is a kind of farming that makes use of information and communication technologies to increase productivity, decrease waste, and enhance environmental friendliness. Sensors, drones, GPS mapping, and other technologies are used in "smart farming" to track variables such as crop development, soil quality, and weather to optimize yields. As well as lowering environmental impacts and increasing food security, "smart farming" has the potential to greatly increase agricultural productivity, sustainability, and profitability. This paper used the ten criteria in smart farming and used the mean weighting method to compute the weights of these criteria and rank them. This paper used the triangular neutrosophic set to deal with uncertain data. We obtained the sustainability criterion as the best. Smart farming could lessen negative effects on the environment and boost agricultural sustainability.

**Data availability**

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

**Conflict of interest**

The authors declare that there is no conflict of interest in the research.

**Ethical approval**

This article does not contain any studies with human participants or animals performed by any of the authors.

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