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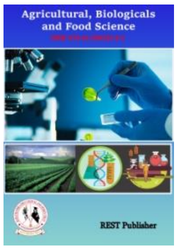

Evaluating Agricultural Production Line Efficiency Using TOPSIS: A Comparative Analysis of Crops and Processing Stages

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***Abstract**: The efficiency of production lines for agriculture products has become paramount in meeting the escalating global demand for food. These lines leverage cutting-edge technologies to optimize productivity and minimize waste. Through the implementation of automated systems, processes from planting and harvesting to sorting and packaging are streamlined. Precision agriculture techniques, such as GPS-guided machinery and sensors, ensure accurate planting and fertilizer application, resulting in maximum yield and reduced environmental impact. Modern irrigation systems, including drip irrigation and precision sprinklers, conserve water resources. Smart sorting machines equipped with computer vision and machine learning algorithms classify and grade produce based on quality, size, and appearance, reducing processing time and human error. Additionally, efficient packaging systems facilitate rapid and standardized packing, reducing labor costs and enhancing product preservation during transportation. The efficiency of production lines for agriculture products not only boosts productivity but also supports sustainable practices and addresses the global food challenge. The research on the efficiency of production lines for agriculture products holds significant importance in addressing critical global challenges. By enhancing the efficiency of these lines, the agricultural industry can meet the increasing demand for food while minimizing resource utilization and waste generation. This research contributes to sustainable agricultural practices by optimizing productivity, reducing environmental impact, and conserving valuable resources such as water and energy. Efficient production lines also have economic implications, as they lower labor costs, improve product quality, and increase profitability for farmers and food producers. Moreover, by streamlining processes and reducing processing time, these lines enable faster delivery of fresh and nutritious food to consumers. Ultimately, the research on the efficiency of production lines for agriculture products plays a vital role in ensuring food security, promoting sustainability, and supporting the well-being of both the industry and the global population. Since TOPSIS is a multi-criteria decision-analytical method, it is given priority. A decision-making technique called TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) ranks alternatives according to how closely they resemble the ideal solution and how far they are from the unfavourable ideal answer. Alternative taken as Wheat, Corn, Soybeans, Oilseed rape, Seeds. Evaluation preference taken as Land preparation, Sowing, replenishment, chemical treatment, Harvest, purification. The first rank goes to Soybeans whereas the last rank goes to Corn. Oilseed rape comes after the first which is followed by Wheat and seeds at the third and fourth places. The analysis is done by TOPSIS method. efficient production lines for agricultural products like wheat, corn, soybeans, and oilseeds are essential for achieving productivity, cost reduction, quality assurance, sustainability, and adaptability. By leveraging technological advancements and adopting innovative farming practices, farmers can optimize their operations, increase profitability, and contribute to a more sustainable and resilient agricultural sector.*

***Keywords:** Production lines, TOPSIS, MCDM, Quality, Agriculture products*

1. INTRODUCTION

Traditional agricultural product logistics information technology is no longer able to satisfy market demands. An key strategy for addressing the nation's current agricultural product logistical issues is the implementation of modern information technology. It is advised that people integrate RFID technology with agricultural product supply chain management mode to manage all aspects of the agricultural product logistics supply chain in a dynamic fashion. By doing this, it will still be possible to offer consumers with high-quality and secure agricultural products while also lowering the expenses connected with logistics and safety monitoring for agricultural products.[3]

The concept of "agriculture 4.0" is the basis for the expression "Agri-Food 4.0," which is compared to "Industry 4.0". Since the concept of Industry 1.0 was introduced by steam engines, and later improved to Industry 2.0 by the use of electricity, the application of technologies has caused a turning point in the industrial revolution by addressing the concept of Industry 3.0. Incorporating the most recent developments in digital technologies and their interoperability process is what Industry 4.0 is all about. [13] Due to rising competition and consolidation, there is more interest in the industrial structure of grain marketing and farm supply cooperatives. Cooperatives for farm supplies and grain marketing have seen significant consolidation during the previous ten years. In nominal terms, net cooperative business volume increased from $72.I billion in 1989 to $104.7 billion in 1998, according to Farmer Cooperative Statistics (Kraenzle et al. 1999). However, there were fewer marketing and agricultural supply cooperatives overall in 1998 than there were in 1987 (4,353 against 3,210), a net loss of 26Y0.The United States' declining number of farmers is one factor contributing to the long-term decline of cooperatives.[2] The form of agricultural products like fruit, vegetables, and grain is one of the most important criteria for their categorization and grading, according to commercial quality and organolectic properties (Morimoto et al. 2000). For the purpose of enhancing human health and developing functional foods, traditional Chinese medicine has extensively used ms [18]. In addition, how fresh agricultural products appear is important when making decisions (Kays 1991).[4]

The diversification of the product market and the competition it entails in terms of quality and variety lessened the benefits of mass production technology. The new need calls for technology that is less productive but more adaptable than the transfer machines, as well as assembly techniques that allow for the construction of slightly more varied goods. In addition to being significantly less expensive than its predecessor, this adaptable technology is also very compatible with the demands of small businesses. [5]. In Europe, a large portion of the land that could be used for agriculture is actually being used for that purpose, but the potential productivity still outpaces the current production by a large margin. There are still many opportunities, even in The Netherlands. This indicates that the rate of production rise per unit of area could be sustained for a period of years basically throughout Europe.[6] How to ensure that farmers' or food producers' perishable products may be purchased by consumers in pristine condition, as well as how to handle shortages and overstocking difficulties, are challenging issues. We use collaborative planning, forecasting, and restocking (CPFR) as a framework to create an agricultural product procurement system strategy to address these issues.

The goal of this study is to create a model for managing the procurement of agricultural products so that forecasting agricultural product demand collaboratively and using shared information will increase forecast accuracy. The advantages include lower inventory losses and lower management costs for buyers.[7] Indirect energy use, or the energy consumed in the manufacturing and transportation of inputs, frequently exceeds on-farm energy usage in modern farming systems in industrialised countries. The two main energy inputs used for agricultural products are fertilisers and imported livestock feed. [10].Most early agricultural scientists understood that farming could not be organised along mass-production lines, in contrast to food processing, which was suited to assembly-line methods. Because there was too much downtime during the production process, it was difficult, if not impossible, to specialise labour along task lines [11].

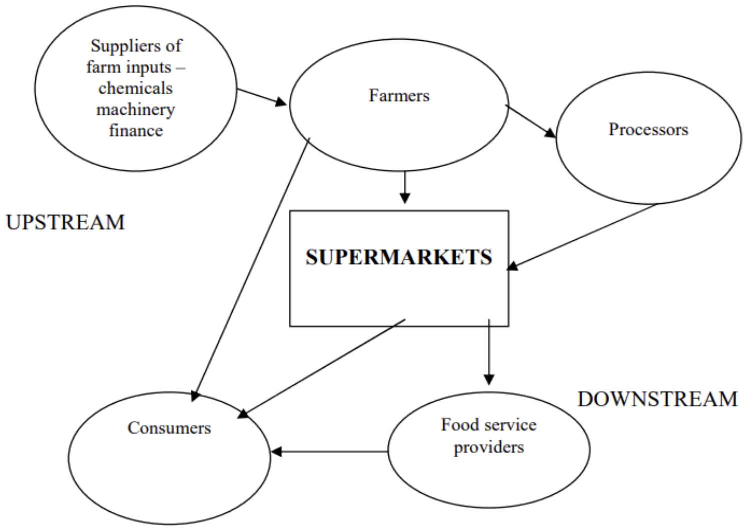

FIGURE 1. supermarkets

Numerous commercially available biobased products currently in use are created by directly treating and processing biomass, such as cellulose, starch, oil, protein, lignin, and terpenes. Despite the size and nature of the changes taking place in the relationship between food and people, there hasn't been much systematic analysis of the ways in which this transformation affects everyone along the supply chain, that is, the actors upstream of the supermarkets (input suppliers, farmers, and processors) and the actors downstream from the supermarkets (food service providers and consumers). It's possible for there to be a lot of food leftover from even farmed farms.

Workers are told to only collect produce that satisfies the bare minimum standards for shape, size, colour, and ripeness. [23]. Farmers' decisions about the size of their operation, their level of production, and their level of specialisation are significantly influenced by local factors, including input and output pricing. Extremely specialised farm businesses almost never take into account the external costs and benefits of agriculture and frequently cause more negative externalities than less specialised ones.[19] Farmers and other stakeholders in the supply chain are becoming more concerned about the effective use of fossil fuels on farms due to variable input prices33,34, the consequences of climate change, and pollution.[1]. Bioeconomy is the sustainable production and transformation of biomass into a range of goods relating to food, health, fibre, industry, and energy. Renewable biomass is any biological resource that can be used as a raw material.[16]

2. MATERIALS & METHODS

Alternative: Wheat, Corn, Soybeans, Oilseed rape, Seeds
Evaluation preference: Land preparation, Sowing, replenishment, chemical treatment, Harvest, purification
Wheat: Wheat is a vital cereal crop in agriculture, widely cultivated for its edible grains. It is utilized in various food products, such as bread, pasta, and cereals, and serves as a crucial source of nutrition and energy for human consumption and livestock feed.
Corn: Mechanization and advancements in corn varieties have improved the efficiency of production lines for corn. This includes reducing labor requirements and optimizing tasks like planting, fertilizing, harvesting, and processing corn crops.
Soybeans: Soybeans are a versatile agricultural crop known for their high protein content. They are used in various food products, including tofu, soy milk, and oil, as well as in animal feed and industrial applications.
Oilseed rape: Oilseed rape, also known as canola, is an important agricultural crop cultivated for its oil-rich seeds. It is used for cooking oil, biodiesel production, and animal feed, contributing to the agricultural and industrial sectors.
Seeds: Seeds are fundamental agricultural products that serve as the starting point for plant growth. They are carefully selected, stored, and planted to ensure optimal crop production and yield in agriculture.
Land preparation: Land preparation is a crucial step in agriculture involving activities like clearing, plowing, and leveling the land to create a favorable environment for planting. It ensures proper seedbed preparation and nutrient availability for optimal crop growth and productivity.
Sowing: The act of sowing is the planting of seeds in ready-made soil. It involves precise placement of seeds at the appropriate depth and spacing to facilitate germination and establish healthy crop stands for agricultural production.
Replenishment: Replenishment in agriculture refers to the practice of restoring nutrients, moisture, or other essential elements to the soil or plants. It involves techniques like fertilization, irrigation, or the application of organic matter to ensure optimal crop growth and productivity.
Chemical treatment: Chemical treatment in agriculture refers to the application of various chemicals, such as pesticides, herbicides, fungicides, or fertilizers, to control pests, weeds, diseases, and provide essential nutrients to crops, ultimately improving their health and yield.
Harvest: Harvest is the process of gathering mature crops from the field. It involves cutting, threshing, or picking crops at the right stage of maturity to obtain the desired yield and quality for agricultural products.
Purification: Purification in the context of agricultural products refers to the removal of impurities, contaminants, or undesirable substances from harvested crops. This process ensures the production of clean, safe, and high-quality agricultural products for consumption or further processing.

TOPSIS Method: To develop a multi-criteria decision-making process, the TOPSIS (Technique for Order Performance by Similarity to Ideal Solution) technique assigns a weighted value to each criterion. The best alternative will be picked depending on whatever alternative is closest to the positive ideal solution, which determines how the alternatives are arranged. The foundation of this approach is the premise that the selected option should be closest to the positive ideal solution and furthest from the negative ideal solution. [1] The 1981 invention of Hwang and Yoon, TOPSIS, is a simple ranking algorithm in terms of idea and application. The classic TOPSIS method looks for alternatives that are both most similar to the ideal solution that is positive and least similar to the ideal solution that is perfect. [6] Various methods have been employed over time to assess and choose the providers. These methods include TOPSIS, neural networks, AHP, fuzzy sets theory, date envelopment, linear programming, cost-based methods, and date envelopment.[8]. The Technique for Order of Preference Approach by Similarity to Ideal Solution (TOPSIS) was utilised to resolve this issue and provide an explanation for the weights that meet the important requirements. [5] The primary economic activity of minorities is typically agriculture. Since the majority of minority communities are situated next to slopes, soil and water conservation are important issues that require more attention. Therefore, timely government action to boost the sales of agricultural goods may greatly raise these minorities' incomes. This research expanded on a Multiple

Criteria Decision Making (MCDM) approach by offering a fuzzy model to include the AHP and fuzzy TOPSIS method in order to enhance a selection process for the established target. [16] AHP, ANP, and TOPSIS are often used techniques when dealing with fuzzy sets. On the other side, fuzzy EDAS is sometimes used to arrive at more susceptible solutions. A well-known decision-making domain is MCDM [15].

The order of preference by resemblance to ideal solution (TOPSIS method) mathematical MCDMA methodology has been extended in numerous uncertain scenarios and used in a range of real-world applications.[4]. One of the MCDA/MCDM methods designed to cope with real-world decision problems is the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), which continues to function well across a range of application domains.[2] Five steps make up the research technique for this study [19]:

Step 1: Construct normalized decision matrix

$$r_{ij} = x_{ij} / \sqrt{(\Sigma x^2_{ij})} \quad \text{for} \quad i = 1, \ldots, m; \; j = 1, \ldots, n \quad (1)$$

where x_{ij} and r_{ij} are original and normalized score of decision matrix , respectively

Step 2: Construct the weighted normalized decision matrix

$$v_{ij} = w_j \, r_{ij} \quad (2)$$

where w_j is the weight for j criterion

Step 3: Determine the positive ideal and negative ideal solutions.

$$A^* = \{ v_1^*, \ldots, v_n^* \}, \quad (3) \quad \text{Positive ideal solution}$$

where $v_j^* = \{ \max (v_{ij}) \text{ if } j \in J ; \; \min (v_{ij}) \text{ if } j \in J' \}$

$$A' = \{ v_1', \ldots, v_n' \}, \quad (4) \quad \text{Negative ideal solution}$$

where $v' = \{ \min (v_{ij}) \text{ if } j \in J ; \; \max (v_{ij}) \text{ if } j \in J' \}$

Step 4: Calculate the separation measures for each alternative.

The separation from positive ideal alternative is:

$$S_i^* = [\Sigma (v_j^* - v_{ij})^2]^{½} \quad i = 1, \ldots, m (5)$$

Similarly, the separation from the negative ideal alternative is:

$$S'_i = [\Sigma (v_j' - v_{ij})^2]^{½} \quad i = 1, \ldots, m \; (6)$$

Step 5: Calculate the relative closeness to the ideal solution C_i^*

$$C_i^* = S'_i / (S_i^* + S'_i) \; , \quad (7) \quad 0 < Ci^* < 1$$

Select the Alternative with C_i^* closest to 1.

FIGURE 2. the research technique

Agriculture's level of sustainability is difficult to gauge. This is brought on by the agricultural sector's high organisational and functional complexity, the variety of output, the variation in the conditions of production in various nations and areas, as well as the complexity of the economic, demographic, and social processes [20]. Various approaches could be used to explain economic phenomena. The model approach, the analytical description, and synthetic measures are frequently employed strategies. The ability to quantify a phenomenon that is described by a large number of features using only one element is the essence of synthetic measurements (Józwiak 2012).[17] In order to execute the fuzzy technique for order of preference by similarity to ideal solution (FTOPSIS), the verbal ratings of each risk component in the risk evaluation are combined with the weights established for the risk evaluation variables. Ranks for each risk item will be defined in accordance with the results of a combined application of TOPSIS, AHP, and FMEA procedures.[13] Quickly determining the optimal alternative is one of TOPSIS' relative advantages (Parkan and Wu, 1997).[10] The technique for order of choice by similarity to ideal solution (TOPSIS) has been used to rate the effectiveness and performance of the agritourism clusters.[7] Fuzzy logic, a subfield of mathematics, gives computer systems the ability to mimic the real world, where humans actually live. This is a simple method for using unclear, contradictory, and false information or knowledge [2].

3. RESULT AND DISCUSSION

TABLE 1. The Efficiency of Production lines for Agricultural Products

Products	Land preparation	Sowing	Replenishment	Chemical treatment	Harvest	Purification
Wheat	2	1	10	2	3	7
Corn	2	1	2	3	3	8
Soybeans	4	5	8	3	5	10
Oilseed rape	6	6	9	1	4	5
Seeds	3	4	1	4	8	2

Table 1 shows Alternative: Wheat, Corn, Soybeans, Oilseed rape, Seeds and Evaluation: Land preparation, Sowing, Replenishment, Chemical treatment, Harvest, Purification

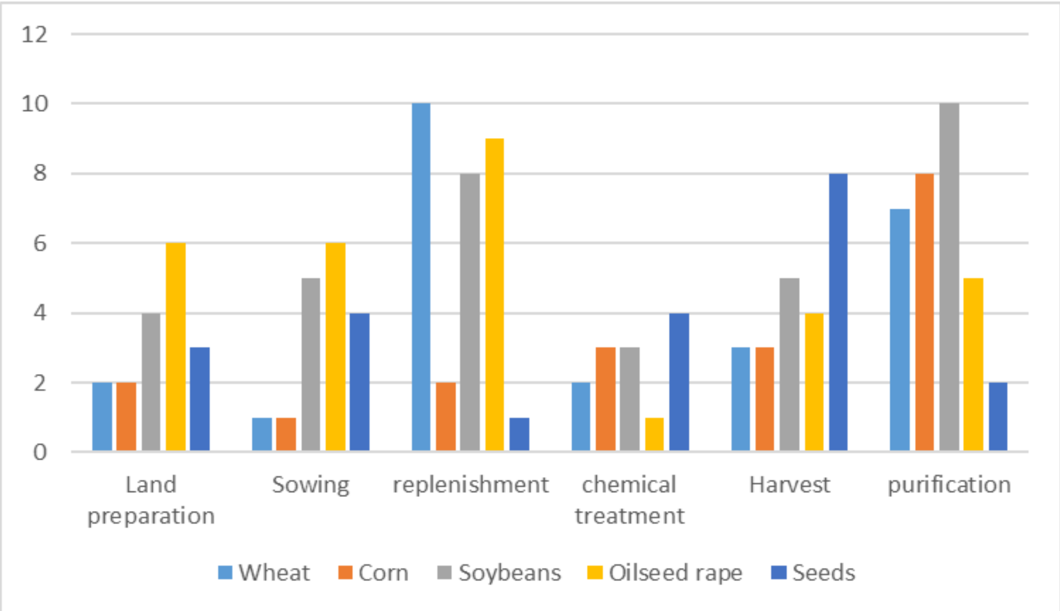

FIGURE 3. The Efficiency of Production lines for Agricultural Products

Figure 3 demonstrates that Soybeans demand the highest level of purification while Wheat requires the best replenishment. Rapeseed for oil needs extensive field preparation and seeding. While maize requires the least sowing, seeds require a large harvest.

Table 2: Normalized Data

Wheat	0.241	0.120	1.204	0.241	0.361	0.843
Corn	0.241	0.120	0.241	0.361	0.361	0.963
Soybeans	0.482	0.602	0.963	0.361	0.602	1.204
Oilseed rape	0.722	0.722	1.083	0.120	0.482	0.602
Seeds	0.361	0.482	0.120	0.482	0.963	0.241

Table 2 shows normalized data of Alternative: Wheat, Corn, Soybeans, Oilseed rape, Seeds and Evaluation: Land preparation, Sowing, Replenishment, Chemical treatment, Harvest, Purification.

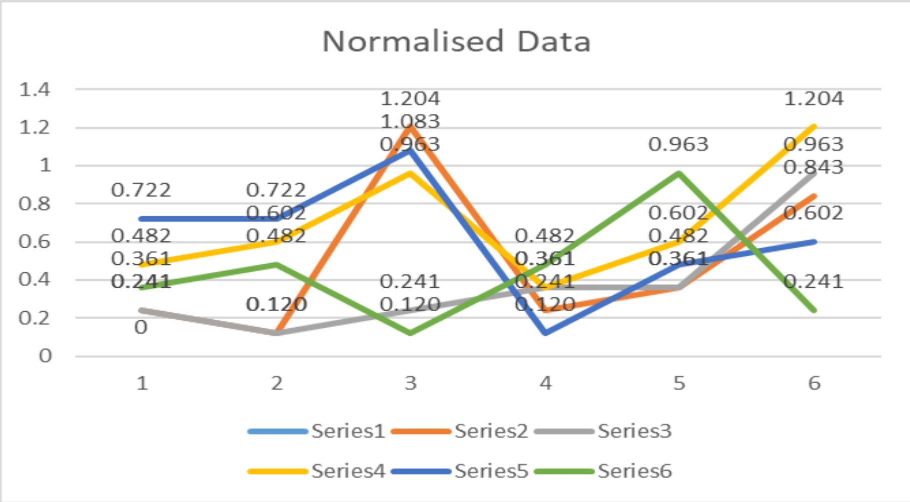

FIGURE 4. Normalized Data

Figure 4 shows the normalised data of Alternative: Wheat, Corn, Soybeans, Oilseed rape, Seeds and Evaluation: Land preparation, Sowing, Replenishment, Chemical treatment, Harvest, Purification.

TABLE 5. Weight

Wheat	0.167	0.167	0.167	0.167	0.167	0.167
Corn	0.167	0.167	0.167	0.167	0.167	0.167
Soybeans	0.167	0.167	0.167	0.167	0.167	0.167
Oilseed rape	0.167	0.167	0.167	0.167	0.167	0.167
Seeds	0.167	0.167	0.167	0.167	0.167	0.167

Table 3 Weight shows the informational set for the weight all same value 0.167.

TABLE 4. Normalized Decision Matrix with Weights

Wheat	0.040	0.020	0.201	0.040	0.060	0.140
Corn	0.040	0.020	0.040	0.060	0.060	0.161
Soybeans	0.080	0.100	0.161	0.060	0.100	0.201
Oilseed rape	0.120	0.120	0.181	0.020	0.080	0.100
Seeds	0.060	0.080	0.020	0.080	0.161	0.040

Table 4 shows the normalized decision matrix with weights of alternative and evaluation parameters.

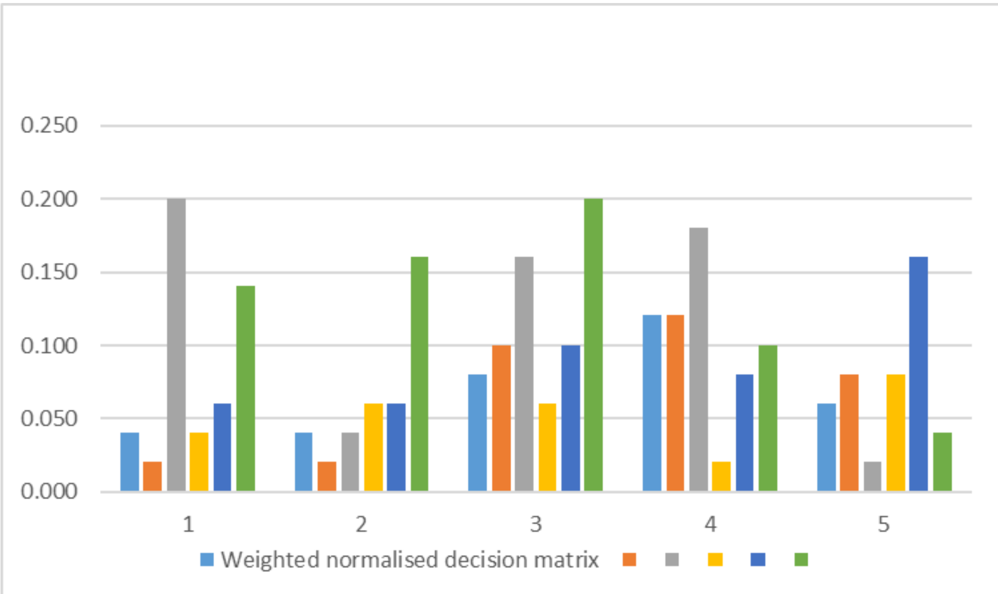

FIGURE 5. Normalized Decision Matrix with Weights

Figure 5 shows the Normalized Decision Matrix with Weights of Alternative: Wheat, Corn, Soybeans, Oilseed rape, Seeds and Evaluation: Land preparation, Sowing, Replenishment, Chemical treatment, Harvest, Purification.

TABLE 5. Positive Matrix

Wheat	0.120	0.120	0.201	0.080	0.161	0.201
Corn	0.120	0.120	0.181	0.080	0.161	0.201
Soybeans	0.120	0.120	0.181	0.080	0.161	0.201
Oilseed rape	0.120	0.120	0.181	0.080	0.161	0.201
Seeds	0.120	0.080	0.020	0.080	0.161	0.201

Table 5 shows the positive matrix of alternative and evaluation parameters.

TABLE 6. Negative Matrix

Wheat	0.040	0.020	0.020	0.020	0.060	0.040
Corn	0.040	0.020	0.020	0.020	0.060	0.040
Soybeans	0.040	0.020	0.020	0.020	0.060	0.040
Oilseed rape	0.040	0.020	0.020	0.020	0.060	0.040
Seeds	0.040	0.020	0.020	0.020	0.060	0.040

Table 6 shows the Negative Matrix of alternative and evaluation parameters.

TABLE 7. Si+, Si-, CI & Rank

	SI Plus	SI -	CI	RANK
Wheat	0.178335	0.207547	1.371	3
Corn	0.219793	0.128474	0.713	5
Soybeans	0.080257	0.23825	3.207	1
Oilseed rape	0.141876	0.215166	1.732	2
Seeds	0.17143	0.133092	0.909	4

Table 7 shows the Si+, Si-, Ci & Rank of alternative and evaluation parameters.

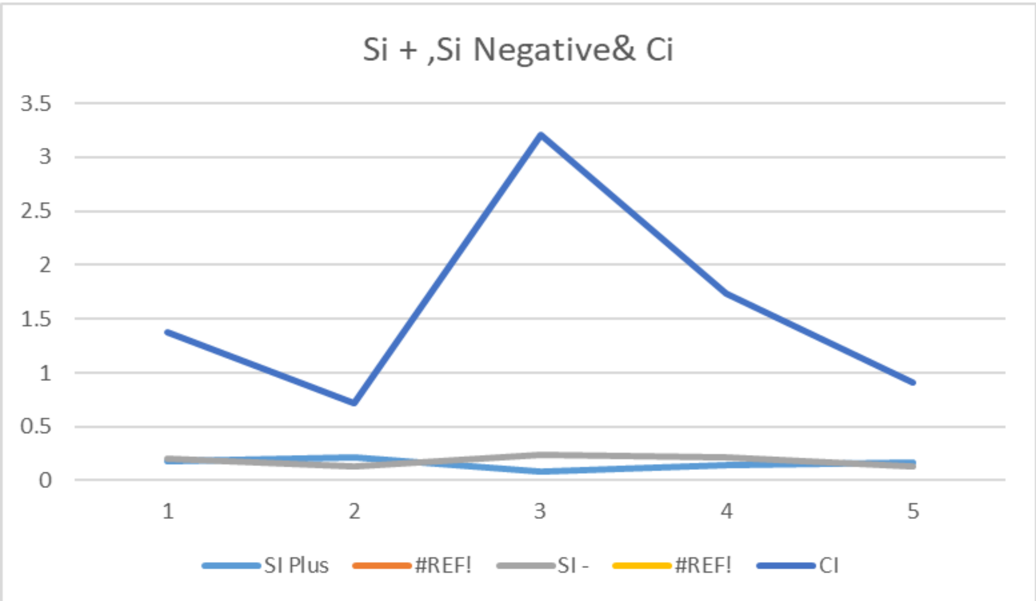

FIGURE 6. Si+, Si- & Ci

Figure 8 shows the Si+, Si & Ci of Alternative: Wheat, Corn, Soybeans, Oilseed rape, Seeds and Evaluation: Land preparation, Sowing, Replenishment, Chemical treatment, Harvest, Purification.

FIGURE 7. Rank

Figure 9 demonstrates that corn comes in last place, while soybeans are ranked top. The second item is oilseed rape, and the third and fourth items are wheat and seeds.

4. CONCLUSION

The efficiency of production lines for agricultural products like wheat, corn, soybeans, and oilseeds (such as rapeseed) plays a crucial role in ensuring a sustainable and profitable farming industry. Efficient production lines enable farmers to maximize their output while minimizing costs, labor, and environmental impact. Increased Productivity: Efficient production lines optimize various aspects of the agricultural process, leading to increased productivity. This can include precision planting techniques, automated harvesting, and streamlined processing and packaging methods. By improving efficiency, farmers can produce higher yields per unit of land, leading to greater profitability and food availability. Cost Reduction: Efficient production lines help reduce operational costs by minimizing waste, optimizing resource allocation, and improving time management. By implementing technologies such as automated machinery, advanced monitoring systems, and data-driven decision-making, farmers can save on labor expenses and optimize the use of fertilizers, water, and energy resources. Quality Assurance: Efficient production lines enable farmers to maintain high-quality standards for their agricultural products. By implementing quality control measures throughout the production process, such as automated sorting and grading systems, farmers can ensure consistent product quality and meet the demands of discerning consumers. This, in turn, enhances market competitiveness and customer satisfaction. Sustainability: Sustainable agriculture is a growing concern, and efficient production lines can contribute to environmental conservation. By minimizing chemical inputs, optimizing water usage, and adopting precision farming techniques, farmers can reduce their ecological footprint. Efficient production lines also enable the integration of renewable energy sources, waste management systems, and conservation practices, promoting sustainable farming practices. Adaptability and Flexibility: Efficient production lines allow farmers to adapt to changing market demands and environmental conditions. With the ability to quickly adjust planting schedules, crop rotations, and production volumes, farmers can respond to market fluctuations and mitigate the risks associated with weather variability, pests, and diseases. This adaptability enhances the resilience of agricultural systems and promotes long-term success. In conclusion, efficient production lines for agricultural products like wheat, corn, soybeans, and oilseeds are essential for achieving productivity, cost reduction, quality assurance, sustainability, and adaptability. By leveraging technological advancements and adopting innovative farming practices, farmers can optimize their operations, increase profitability, and contribute to a more sustainable and resilient agricultural sector.

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