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Evaluation of a Smart System in Agriculture Using Fuzzy ARAS Method

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Abstract

Over 9 billion people are predicted to live on the planet, and food demand will increase by 50%. In addition, climate change may cause a 10% decline in agricultural output. Multi-layered farms are a realistic way to generate additional food from unit areas because arable land is stable. It makes sense to use smart technology to help with productivity in these farms that resemble factories. The use of information and communication technologies on equipment is known as "smart farming" (SF); It includes applications in agricultural production systems in equipment and sensors. Modern innovations like cloud computing and the internet of things Growth should be stimulated by this, Also the introduction of robots and artificial intelligence in agriculture. When estimating the amount of food produced in a season, An indoor hectare of a vertical farm, 30 hectares of land can produce the same yield using 70% less water without the use of pesticides. Cohesion was shown to be one of the major elements influencing SF evolution among the many systems on the market. Farmers' education, abilities, and capacity to comprehend and use SF instruments are further constraints. These restrictions made it possible for businesses to study and resolve these issues, and science can aid with this process. In this study, we used MCDM methodologies to assess the three vertical farm technology possibilities. Although commercial vertical farms have been established in several nations, the industry is still developing, and it is challenging to obtain reliable statistics. Therefore, to the greatest extent possible, fuzzy logic was applied to address the pertinent uncertainties. Alternatives: fundamental, IoT, and automation Assessment Factors that affect venture capital include manufacturing methods that are efficient, the need for labor, security concerns, location, and demand, as well as R&D capabilities and expansion potential. Results: IoT is ranked first and Basic is ranked lowest. Resulting in IOT ranked first, There Basic has a low rank.

Keywords: Internet of Things, smart farming, fuzzy MCDM methods

Introduction

Internet of Things in the Agriculture Sector, Big data, and smart technologies are now widely used, which has led to the development of smart agriculture. [1], [2] Smart agriculture is based on current technologies such as smartphones, IT Platforms, Cloud Services, Big Data, Internet of Things, 3S integrates technologies and experts' knowledge and expertise, [3], [4]. Agriculture. Precision agriculture, smart water management, agricultural monitoring, monitoring agricultural practices, And the quality and safety of agricultural products are smart agriculture overall better and Some ways to contribute to efficient farming and, Ultimately, a more sustainable food supply chain[5]. Transformation and development of the agricultural sector will help promote the long-term growth of agriculture Supported by the laws or administrative regulations of many countries. To create a new model of smart agriculture development, Encouraging agribusinesses that already have smart farming solutions is critical. Limitations imposed by conventional agricultural management software and Farmers are finding it difficult to use agricultural smart solutions due to the lack of technical capability of agricultural companies. [6] With smart farming solutions on the market today that vary widely in terms of technical quality, benefits, and management methods, Agribusinesses find it difficult to make an informed decision. To make matters more complicated, the Successful implementation of a smart agriculture solution will require a significant amount of resources, both monetary and human capital. [7]A company's decision to go with smart farming solutions should be supported by a reasonable assessment of available alternatives. Agricultural solutions are evaluated and selected Smart Agriculture Internet in the field of agriculture, has evolved as a result of the widespread use of big data and smart technology. [1], [2] Smart agriculture is based on smartphones, IT Platforms, Cloud Services, Big Data, the Internet of Things, 3S technologies and expert knowledge and expertise, [3], [4], etc Integrates current technologies. Precision agriculture, smart water management, agricultural monitoring, Monitoring agricultural practices, and quality and safety of agricultural produce are Some of the ways smart agriculture contributes to overall better and more efficient agriculture and Ultimately, a more sustainable food supply chain[5]. Transformation of the agricultural sector and Development is supported by many countries laws or administrative regulations that help promote long-term growth in agriculture. To create a new model of smart agricultural development, Encouraging agribusinesses that already have smart farming solutions is critical. limitations imposed by conventional agricultural management software Due to the lack of technical capacity of agricultural enterprises Farmers are finding it difficult to use agricultural smart solutions. [6] With smart farming solutions on the market today that vary widely in terms of technical quality, benefits, and management methods, Agribusinesses find it difficult to make an informed decision. To make matters more complicated, To successfully implement a smart farming solution, cash and A significant amount of resources will be required, both in terms of human capital. [7]A company's decision to go with smart farming solutions should be supported by a reasonable assessment of available alternatives. Agricultural solutions are evaluated and selected.

Three options—basic, IoT, and automated vertical farms—were covered in this study. The foundation for all three alternatives is a soilless hydroponic system with 200 m2 of usable space. Fuzzy ARAS methods for multiple criteria decision-making (MCDM) were utilized to assess such options. We used fuzzy logic whenever feasible because the field is young and there aren't many data points accessible. As the first study to evaluate technology investment and choice in agriculture, we hope that this work adds to the body of literature. It can be utilized as a reference source by researchers in other studies was one of the criteria for choosing this study. With fuzzy preference ratings, we have modified the fuzzy ARAS technique utilized by group decision-makers. Both approaches used in our experiments discovered a fresh field of utilization. One of the key industries where IoT-based research is taking place and new products are being released every day is "agriculture," which improves operations and increases efficiency for improved production. Globally, the agriculture industry is regarded as being the most crucial one for maintaining food security. I'm referring to Indian farmers, who are presently struggling and at a disadvantage because of factors such as farm size, technology, trade, government laws, environmental factors, etc. ICT-based methods have addressed some of the issues, but not all of them. reliable and effective manufacturing. Recently, IoT, commonly referred to as "ubiquitous computing," has displaced ICT (Patil et al., 2012). Numerous tasks are necessary for agricultural production, including monitoring of the soil, plants, and environment (including temperature and humidity), transportation, supply chain management, infrastructure management, control system management, animal monitoring, and pest control. Fuzzy theory [21]–[23] combined with MCDM approaches [24]–[27] A robust for generating reliable results in various decision domains and useful tool. Decision-making process, especially when dealing with complex situations, Pre-defined and specific elements must be met. According to Zavatskas et al [29], Multi-criteria decision-making in science plays a specific role.Decision Makers (DM) are available to achieve their goals Used to determine a suitable alternative from a set of alternatives. If we deal with a real-world problem, Decision-making processes We see it as a complex problem. Complicated, interconnected, or occasionally Due to competing aims, the selection problem becomes more challenging [1, 2]. This paper's primary contribution can be summed up as follows: Identify the range of fuzzy design graph options. Consider those options, In order to make a decision, compare the alternatives that have been considered.

Materials and Method

Researchers are becoming more interested in smart farming and related fields, But there is no pre-screening when it comes to technology choice and MCDM in smart farming. In the absence of previous literature, Experts and scholars are key contributors in selecting evaluation criteria. a company that provides technology to farmers who use closed ecosystems The Autogrow online census [1] was quite beneficial to us. We came up with the following standards for assessing potential solutions: (C1) Attracting venture capital: One of the most popular agricultural techniques in greenhouses is hydroponics. Indoor farming, however, is still a niche activity. Most firms need subsidies and outside capital because the method's economics aren't yet viable for mass adoption. We asked professionals to assess the appeal of alternatives to getting funds. (C2) Effective production methods: The production environment is indoor farming's largest perk. A farmer can set up the ideal environment for plant development. Keep an eye on the producer market, assess the production accordingly, and balance diversity. No matter how automated the farm is, the need for labor is a constant (C3). Given the intricacy of the manufacturing process, a workforce with education is beneficial. Labor costs rise when prior on-the-job training is used. (C4) Safety: The company's manufacturing facility can be customized, and the manufacturing method is adaptable. The company's primary assets include its manufacturing process, cyber security, and agricultural rotations. Vertical farming increases crop volume per unit land ratio (C5) Location Required. Indian land is a scarce and valuable resource. The producer is responsible for allocating the available space. R&D capability (C6) Since environmental factors are entirely flexible, it is possible to establish new species of local plants and rare plants. Crop rotation can be reduced using alternative approaches, which also have many benefits for improving product quality. (C7) Investment and upkeep expenses: Indoor farming requires scarce urban land and pricey production equipment. It is an intricate mechanism. Depending on the options, different initial investments are required. the first, most straightforward, A simple layout. The organization runs like a regular farm. The farmer manually monitors the farm's core principles. Growers' values for pH, EC, humidity, and temperature are closely followed. The IoT-based second option benefits from IoT capabilities. Sensors are used to gather the agricultural values described above. By the data gathered, the farmer activates the system. The farmer may view the farm from a distance thanks to the integration of the IoT system. The Internet of Things (IoT) has revolutionized every aspect of the lives of the average person by making everything smarter and smarter. IoT refers to a collection of interconnected devices that can self-configure. IoT underpins intelligent smart farming. The improvement, cost-effectiveness, and reduction of waste brought about by the development of tools are changing the face of agricultural production every day. Farmers employ a new smart IoT-based agricultural stick for effective environmental monitoring as the paper's goal or objective. It is suggested to get direct information (temperature, soil moisture). The article's suggested agricultural implementation incorporates Arduino technology. A breadboard packed with a variety of sensors and a live data feed is accessible online at Thingspeak.com. Production in fields intended for direct agriculture More than 98% accuracy is provided by tested and in data feeds. Automation is a third option that combines automation and AI support. Human intervention is decreased by automation. Following the data gathered, the system will take the appropriate actions. For instance, it automatically heats up when the temperature dips to a predetermined level. controls HVAC (heating, ventilation, and air conditioning) systems. AI has the potential to improve manufacturing techniques. Plant growth data is analyzed by machine learning algorithms to harvest the best plant. Each solution has a different setup price. It is simple to get the required resources because indoor agriculture is a topic that is of great interest. MCDM stands for operations research is an advanced field; It is the decision maker and Comprehensive for researchers and is more relevant to the complexity of economic decision-making problems and offers a wide range of methods [1]. For the evaluation of twenty-four companies in this study, two fuzzy MCDM methods were used. First, the FAHP core criteria and used to determine the weights of the sub-criteria, Then the researcher used Fuzzy ARAS He ranked companies based on best financial performance. Admission Rate Assessment (ARAS), is founded on the premise that phenomena in the complex world can be comprehended using straightforward relative comparisons, which Zavadskas and Zavadskas (2010) introduced (Turskis, Zavadskas 2010). The ARAS technique calculates the ratio of each alternative to the best alternative in addition to the performance of the alternatives. The decision-making body and the relative relevance of the assessment criteria are under the fundamental principles of the ARAS technique; it is possible depending on the criteria taken into account utilizing numerical values, to offer reviews of alternatives as well. Real-world issues are taken into account using dependent criteria to calculate precise weights for alternatives frequently challenging for the decision-maker (Yazdani-Chamzini, Yakhchali 2012). The advantage of employing a fuzzy approach is that it can better fit actual events than using precise numbers. Utilizing fuzzy numbers to determine the preference or relevance of a criterion To more properly formulate real-world situations, fuzzy logic, and ARAS technology are coupled to create the fuzzy ARAS method. The fuzzy ARAS approach aids the decision-making team in doing in-depth analysis when there is ambiguous or inaccurate information present to prioritize an alternate option.

Result and Discussion

Table 1 evaluation parameter

C1	Venture Capital Attractivenes
C2	Effective Manufacturing Processes
C3	Workforce Requirement
C4	security
C5	Space Requirement
C6	R&D Capabilities
C7	Investment and Maintenance Costs

Table 1 shows in evaluation parameter factors. Here C1 stands for Venture Capital Attractiveness, C2 stands for Effective Manufacturing Processes, C3 stands for Workforce Requirement, C4 stands for security, C5 stands for Space Requirement, C6 stands for R&D Capabilities, C7 stands for Investment and Maintenance Costs.

Table 2 Criterion Weights

Criterion Weights	
Medium	(3, 5,7)
High	(7,9,1)
Very High	(9,1,1)

Table 2 shows the scale value of Medium, High, and Very High stands for fair, this is fuzzy numbers.

Table 3 Formula for criterion weight

	C1	C2	C3	C4	C5	C6	C7
Basic	M	H	H	VH	H	VH	M
IoT	H	M	VH	H	M	M	H
Automation	VH	M	H	H	VH	H	H

The codes for C1, C2, C3, C4, C5, C6, and C7 are shown in Table 3 above. The value of Table 2 is adjusted to appear above each column of Table 2 in each column of the criterion index.

Table 4 solved value of l', l, m, u', u

	l	l'	m	u'	u
C1	3	5.738794	7.66309	8.879	10
C2	3	3.979057	6.0822	7.8837	10
C3	7	7.611663	9.3217	10	10
C4	7	7.611663	9.3217	10	10
C5	3	5.738794	7.66309	8.879	10
C6	3	5.738794	7.66309	8.879	10
C7	3	5.277632	7.39864	8.879	10

Table 4 demonstrates that column (l) in Table 2's modified value column (l) indicates the minimum first value of all criterion weights. (l'), as shown in Table 2, represents the cube root of the first modified value's product. The cube root of the product of the second modified value in Table 2 is specified in (m). (u') Give the cube root of the third value's product. (u) Indicate the adjusted scale weight in Table 2 with the third-highest value.

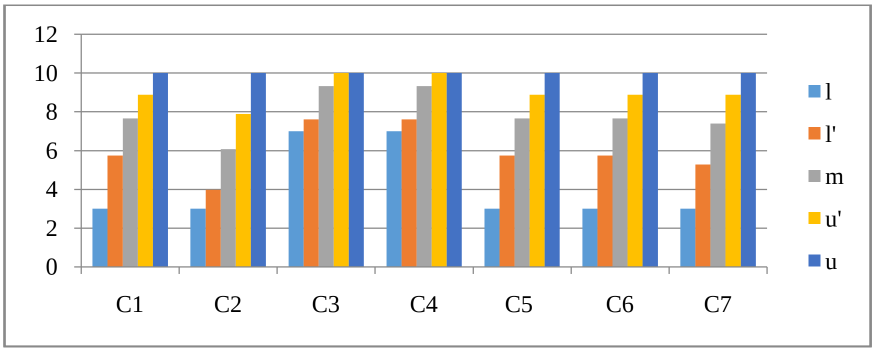

FIGURE 1 Criterion Weights

A visual representation of Table 4 is shown in Figure 1. This proves that u in C1, C2, C3, C4, C5, C6, and C7 all have the same value of 1. Compared to all other benchmarks, C4 is heavier.

Table 5 Performance Rating

Performance Rating	
F	4,5,6
MG	6,7,8
G	8,9,10
VG	9,10,10

Table 5 shows the performance rating of F, MG, G, and VG. F represents fail, MG represents medium good, G represents good, and VG represents Very good. All the above value mentions the rating of the performance.

Table 6 Number for place which represent the column and row of the above tabulation

Optimal	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
M1	1,1	1,2	1,3	1,4	1,5	1,6	1,7
M2	2,1	2,2	2,3	2,4	2,5	2,6	2,7
M3	3,1	3,2	3,3	3,4	3,5	3,6	3,7

Table 6 shows the number of the place which represents the column and row of the above tabulation.

Table 7 Formula to calculate the Performance rating

	C1	C2	C3	C4	C5	C6	C7
M1	MG, G,VG	F,MG,G	MG,VG,F	F,MG,VG	VG,MG,G	G,MG,VG	F,MG,VG
M2	F,VG,MG	G,MG,VG	VG,MG,G	VG,MG,G	MG,VG,F	MG,VG,G	F,G,MG
M3	F,G,MG	MG,VG,G	VG,G,MG	MG,G,F	MG, G,VG	MG,G,F	MG,VG,G

By entering the value from Table 5 into Table 6, Table 7 shows the formula for each box in the table. To determine the following value, repeat this procedure for each row and column.

Table 8 solved value of l', l, m, u', u for Performance rating

	l	l'	m	u'	u
1,1	6	7.559526	8.57262	9.2832	10
1,2	3	4.717694	6.25732	8.5726	10
1,3	3	5.129928	7.0473	8.5726	10
1,4	3	5.129928	7.0473	8.5726	10
1,5	6	7.559526	8.57262	9.2832	10
1,6	6	7.559526	8.57262	9.2832	10
1,7	4	6	7.0473	7.8297	10
2,1	3	5.129928	7.0473	8.5726	10
2,2	6	7.559526	8.57262	9.2832	10
2,3	6	7.559526	8.57262	9.2832	10
2,4	6	7.559526	8.57262	9.2832	10
2,5	4	6	7.0473	7.8297	10
2,6	6	7.559526	8.57262	9.2832	10
2,7	4	5.768998	6.80409	7.8297	10
3,1	3	4.717694	6.25732	8.5726	10
3,2	6	7.559526	8.57262	9.2832	10
3,3	6	7.559526	8.57262	9.2832	10
3,4	3	4.717694	6.25732	8.5726	10
3,5	6	7.559526	8.57262	9.2832	10

3,6	4	5.768998	6.80409	7.8297	10
3,7	6	7.559526	8.57262	9.2832	10

Table 8 shows that column (l) specifies the minimum first value of all criterion weights, which is the modified value in Table 7. As indicated in Table 6, the cube root (l') of the product of the first transformed value. (m) specifies the cube root of the product of the modified second value in Table 7. (u') State the cube root of the product of the third value. (u) Specify the third highest value of all modified scale weights in Table 7.

Table 9 sum of solved value of l', l, m, u', u

A01	6	7.559526	8.57262	9.2832	10
A02	6	7.559526	8.57262	9.2832	10
A03	6	7.559526	8.57262	9.2832	10
A04	6	7.559526	8.57262	9.2832	10
A05	6	7.559526	8.57262	9.2832	10
A06	6	7.559526	8.57262	9.2832	10
A07	6	7.559526	8.57262	9.2832	10

Table 9 displays each box's maximum size about Table 8. The highest row and column totals are taken into account.

Table 10 Weighted Normalized Matrix C1

Weighted Normalized Matrix C1					
A0	4.5	10.84564	16.4232	20.606	25
M1	4.5	10.84564	16.4232	20.606	25
M2	2.25	7.359899	13.501	19.029	25
M3	2.25	6.768468	11.9876	19.029	25

The value of C1 calculated from all the above calculations is shown in Table 10. It shows the weighted normalized C1 matrix representing the spread of the economy.

Table 11 Weighted Normalized Matrix C2

Weighted Normalized Matrix C2					
A0	4.5	7.519947	13.0351	18.297	25
M1	2.25	4.692994	9.51458	16.896	25
M2	4.5	7.519947	13.0351	18.297	25
M3	4.5	7.519947	13.0351	18.297	25

Table 11 represents the value calculation of the C2from all the other calculation done on the above. It shows the weighted normalized matrix of C2 which represent social distribution.

Table 12 Weighted Normalized Matrix C3

Weighted Normalized Matrix C3					
A0	10.5	14.38514	19.9778	23.208	25
M1	5.25	9.76182	16.4232	21.432	25
M2	10.5	14.38514	19.9778	23.208	25
M3	10.5	14.38514	19.9778	23.208	25

Table 12 represents the value calculation of the C3 from all the other calculation done on the above. It shows the weighted normalized matrix of C3 which represent air pollution.

Table 13 Weighted Normalized Matrix C4

Weighted Normalized Matrix C4					
A0	10.5	14.38514	19.9778	23.208	25
M1	5.25	9.76182	16.4232	21.432	25
M2	10.5	14.38514	19.9778	23.208	25
M3	5.25	8.977374	14.5822	21.432	25

Table 13 represents the value calculation of the C4 from all the other calculation done on the above. It shows the weighted normalized matrix of C4 which represent water pollution.

Table 14 Weighted Normalized Matrix C5

Weighted Normalized Matrix C5					
A0	10.5	14.38514	19.9778	23.208	25
M1	5.25	9.76182	16.4232	21.432	25
M2	10.5	14.38514	19.9778	23.208	25
M3	5.25	8.977374	14.5822	21.432	25

Table 14 represents the value calculation of the C5 from all the other calculation done on the above. It shows the weighted normalized matrix of C5 which represent water pollution.

Table 15 Weighted Normalized Matrix C6

Weighted Normalized Matrix C6					
A0	10.5	14.38514	19.9778	23.208	25
M1	5.25	9.76182	16.4232	21.432	25
M2	10.5	14.38514	19.9778	23.208	25
M3	5.25	8.977374	14.5822	21.432	25

Table 15 represents the value calculation of the C6 from all the other calculation done on the above. It shows the weighted normalized matrix of C6 which represent water pollution.

Table 16 Weighted Normalized Matrix C7

Weighted Normalized Matrix C7					
A0	10.5	14.38514	19.9778	23.208	25
M1	5.25	9.76182	16.4232	21.432	25
M2	10.5	14.38514	19.9778	23.208	25
M3	5.25	8.977374	14.5822	21.432	25

Table 16 represents the value calculation of the C7 from all the other calculation done on the above. It shows the weighted normalized matrix of C7 which represent water pollution.

Table 17 Si values

	Si				
A0	61.5	90.29129	129.347	154.94	175
M1	33	64.34773	108.054	144.66	175
M2	59.25	86.80555	126.425	153.37	175
M3	38.25	64.58305	103.329	146.26	175

Table 17 shows the sum of all C1, C2, C3, C4, C5, C6, and C7 of all weighted normalized matrices for all rows and columns of every box in the tabulation.

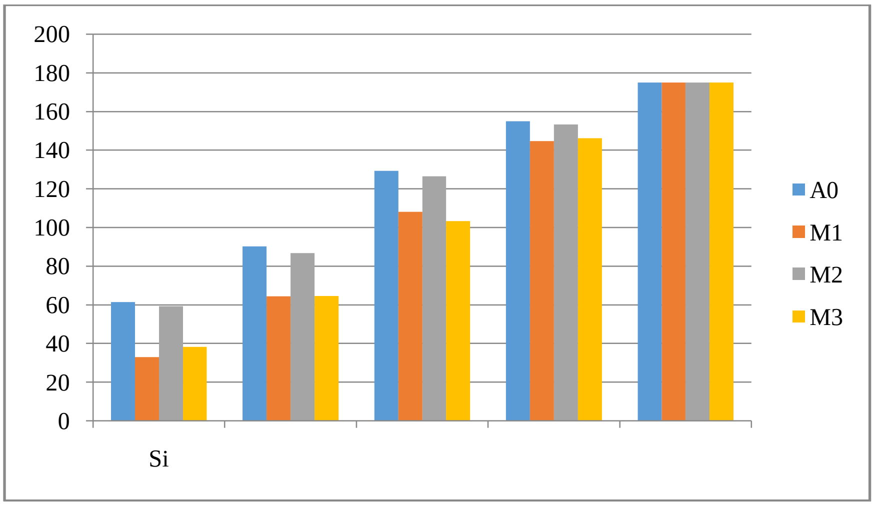

FIGURE 2 Sum of all weighted normalized matrix

Figure 11 shows the sum of all weighted normalized matrices it is the pictorial representation to show the easy way of all C1 to C7.

Table 18 Si, Qi

	Si	Qi
A0	122.2163	1
M1	105.0123	0.859234
M2	120.1693	0.983251
M3	105.4845	0.863097

Table 18 shows the sum of table 17 which is divided by five to give the rank of all Si. The M2 is in the first rank and the M1 is in the last rank.

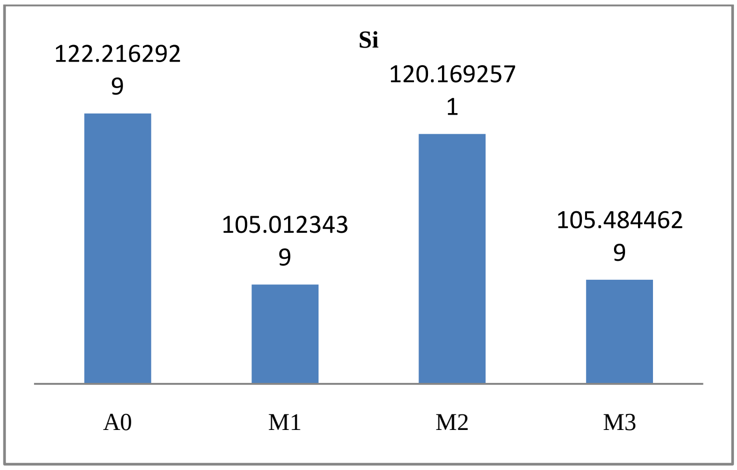

FIGURE 3 Shown in Si

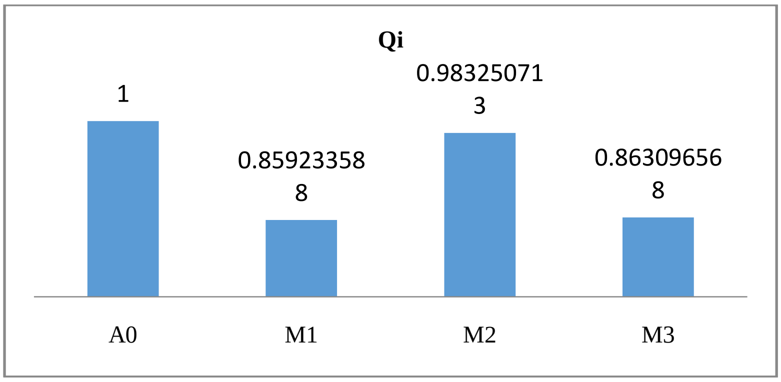

FIGURE 4 Shown in Qi

Figure 3 and figure 4 is showing A0, M1, M2, and M3 in Si and Qi.

Table 19 Rank

M1	Basic	3
M2	IoT	1
M3	Automation	2

Table 19 shows that the rank depends on smart farming in agriculture. According to smart farming, the IoT is in 1st rank, Basic is in 3rd rank, and Automation is in 2nd rank seen in figure 5.

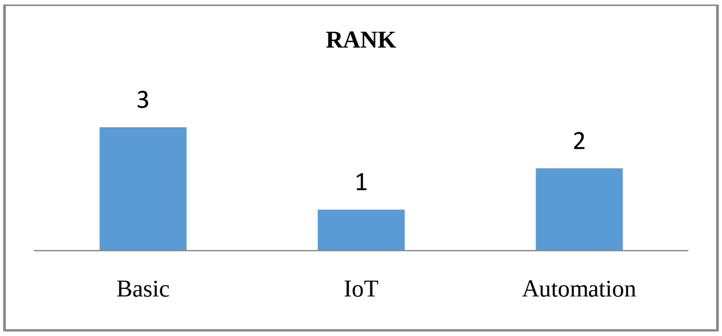

FIGURE 5 Shown in Rank

Conclusion

Agriculture was altered by the Industrial Revolution and synthetic fertilizers. Over the past few decades, mechanized farming has been the standard. The precision agricultural paradigm will shift as a result of the digital era. Urbanization, climate change, and global warming are pressing issues that need to be addressed. One of the sustainable solutions is indoor farming. Water, insecticides, and fuel usage are reduced while using hydroponics. Urban agriculture is one method for assisting environmentally conscious communities to become self-sustaining communities. We modified the earlier MCTM approach to accommodate multiple decision-makers. We got consistent results using this strategy, and it responded well to our adaptation. To verify the accuracy of the proposed method Fuzzy ARAS method is also used. Fuzzy ARAS method By comparing each option with the other, Inconsistencies can be detected during operation. Both methods produced comparable results. For Indian agriculture, the report suggested technology options. To the best of our knowledge, this study is the first to look at the use of MCDM methodologies in the selection of technology for agricultural practices. Automation alternatives outperformed other alternatives according to fuzzy ARAS methods. Decision makers' R&D capabilities and emphasis on employee needs, the results are reasonable. Real options valuation or the net present value technique may be options for future study. Alternative design and optimization studies are feasible. Different MCDM techniques can be utilized for modified alternatives. A direct temperature monitoring system for soil moisture employing Arduino, cloud computing, solar technology, and the internet of things are suggested. Concerning temperature and soil moisture getting live data is more efficient And accurate. Agriculture as proposed by this thesis, Increase agricultural productivity for farmers, It will also help in the effective management of food production Because environmental temperature with more than 99% accurate results and accuracy of soil moisture is always helpful for farmers to get live food.

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