



A DEMATEL Analysis of the Complex Barriers Hindering Digitalization Technology Adoption in the Malaysia Agriculture Sector

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Abstract

This study investigates the challenges to the digitalization technology adoption in Malaysia agriculture sector by using the DEMATEL (Decision-Making Trial and Evaluation Laboratory) approach, which will give a complete knowledge of the interdependencies among the barriers. The research objectives are to determine the cause and effect of digital agriculture using DEMATEL and to recommend the best way to overcome the obstacles in using digital technology. The findings from this study reveals the cause and effect from the barriers which is lack of skills, lack of technology, high cost, infrastructure and connectivity, and resistance to change are in the cause group while limited locality, data privacy and security concerns, low level of education, market access and regulatory and policy are in the effect group. The research findings are utilized to give policymakers and stakeholders with practical recommendations aimed at addressing the identified barriers and promoting the adoption of digital technologies in Malaysian agriculture. Thus, this study offers recommendations for the most important obstacles found, which are an improvement in infrastructure and the implementation of financial assistance mechanisms. All things considered, this research makes a significant contribution to the subject of agriculture and sheds light on the difficulties associated with implementing new technologies in Malaysia's agriculture industry.

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1. Introduction

Digitalization and its implementation in the agricultural industry are becoming more and more popular, particularly in the context of barriers and challenges. Many surveys have investigated the obstacles that hinder the use of digital technologies in agricultural practice and show the multidimensionality and variability of this process [1]. Real and perceived relevance, as well as privacy and security issues, have been identified as major obstacles to adoption of technology in agriculture, especially for small-scale farms [2][3]. In addition, technology costs have been identified as a barrier to the adoption of smart farming practices [4]. The barriers when combined with the challenges of businesses in the use and adaptation of digital technology affect the sustainability and productivity of the sector [5].

In the context of Malaysia, the difficulty of technology adoption among manufacturing SMEs is well studied, and the key is to overcome the obstacle for them to be competitive in the world market [6]. Furthermore, emphasis on the need for Malaysian organizations to adopt Industry 4.0 has been made, where it was described, that digital technologies should be extended beyond mobile and cloud computing [7][8]. Significant attention had been paid on the innovative capabilities of technologies in changing sustainable food systems, in which emerging technologies were proposed, including the Internet of Things, artificial intelligence, and drones in agriculture [9]. The literature also discusses the demand for the policy instruments that would stimulate the adoption of digital agricultural technologies, mainly for environmental services, as well as to decrease inequalities associated with the digital technologies in agriculture development and adoption [10][11]. Besides, the level of technology adoption in the Malaysian museums for the purpose of sustainable heritage tourism is evaluated, which indicates the wider context of digital technology adoption in other fields as well [12].

The application of Artificial Intelligence (AI) in the agriculture sector has become an attractive area of study in the past several years to some extent because it has the potential to resolve some of the critical problems of conventional agriculture Alreshidi [13]. AI is used in several agricultural domains such as robotic farming, plant disease management, and precision agriculture [14][15][16]. These examples show the variety of applications of AI in agriculture such as robotic farming and environmentally friendly agricultural sustainability. Yet, there are some challenges that prevent AI integration in agriculture such as cost of integration, expertise level, and need for human interaction, which reduce the rate of its acceptance [17][18][19]. Transparent and accountable use of AI in digital agriculture is accentuated considering ethics [20]. Research mainly deals with the applied technical side of AI technologies in enhancing agricultural practices and identifying the constraints of AI adoption [16]. Furthermore, the possible effects of AI applications in agriculture on the use of labor and productivity were investigated revealing that countries that adopt the AI solutions faster, can get a competitive advantage in food production [21].

Next, Decision-Making Trial and Evaluation Laboratory (DEMATEL) is frequently applied method for analysis of complicated decision-making problems by determination and evaluation of the factors' causes and effects. The areas where DEMATEL has been used include but are not limited to agriculture, supply chain management, healthcare, and technology adoption. The purpose of this literature review is to present a review of the research done on DEMATEL and the uses of it in the process of making decisions. Concerning agriculture, Mangla et al. [22] listed enablers to implement sustainability initiatives in agri-food supply chains by carrying out a comprehensive literature review and expert consultation. This shows the capability of DEMATEL in evaluating and ranking factors that lead to the effective implementation of sustainability initiatives in the agricultural sector.

Additionally, the usage of DEMATEL in technology adoption is investigated in several research works. Bajpai & Misra [23] used the fuzzy-DEMATEL technique to investigate barriers to implementing digitalization in the Indian construction industry, demonstrating that DEMATEL is effective in identifying critical barriers from extensive literature review and interviews with industry professionals. Likewise, Zaman et al. [24] used DEMATEL in examining how digitalization in banking enhances service supply chain resilience in the e-commerce sector, thereby indicating the applicability of DEMATEL in the evaluation of technology adoption and its effects on supply chain dynamics.

Apart from agriculture and technology adoption, in health care, environmental management and circular economy initiatives, the DEMATEL is used. Gupta et al. [25] determined enablers for service quality in the health care sector using DEMATEL, focusing on the contribution of DEMATEL in evaluation and comprehension of multi-dimensional factors affecting service quality. Sundar et al. [26] used DEMATEL to analyze the transition barriers in the e-waste management sector of the UK, indicating the versatility of the DEMATEL approach for the understanding and solving transition challenges in the circular economy. While Rodzi et al. [27] used DEMATEL method to reveal barriers of household waste recycling in Seremban, Malaysia. The study showed that using DEMATEL method was effective to identify and assess casual relationships among the factors of household waste recycling.

The research intends to identify and understand the complex web of obstacles impeding the adoption and utilization of digital technologies in the agriculture sector of Malaysia through rigorous investigation. This research is mainly aimed to use the DEMATEL method as a systematic tool for the analysis and evaluation of the interrelationships of different obstacles that impede the application of digitalization technology in the Malaysian agriculture. The use of DEMATEL allows the study to untie the causal links between these barriers providing a wide understanding of their interconnection and relative importance in preventing the development of digitalization technology adoption in the Malaysian agricultural environment.

To that effect, the study also attempts to articulate specific aims geared towards the accomplishment of an in-depth analysis of the barriers to digitalization technology adoption in Malaysian agribusiness. Initially, this research attempts to inventory and classify the multitude of obstacles that hinder the adoption of digital technologies in Malaysian agricultural sector, including but not limited to financial impediments and technological complications. Secondly, the research aims to measure the degree of influence and interdependency of these identified barriers by employing DEMATEL method, hence delineating the main factors that acts as key drivers of resistance to digitalization technology adoption in Malaysian agricultural setting. Finally, the research seeks to offer practical recommendations of the DEMATEL analysis aimed at policymakers, industry stakeholders, and other relevant authorities on how to overcome the detected barriers and to create an enabling environment for the widespread usage of digitalization technology in the Malaysian agriculture. The objectives will, thereby, be helpful to the Malaysian agricultural sector transformation, the focus of which is on the greater efficiency, sustainability, and resilience in the digital era, as the study seeks to provide useful information on how to overcome the challenges associated with digitalization technology adoption.

2. Research Methodology

In this study, there are several phases in determining the barriers hindering digitalization technology for the agricultural sector. In the first phase, a literature review was done to justify the barriers in any country. Following the Decision-Making Trial and Evaluation Laboratory (DEMATEL), the process is applied to analyze the adoption of agriculture. The flowchart above shows how the project is carried out.

In the phase of data collection, data and information will be obtained from the questionnaire that has already been set up. Data must be gathered from professionals in the agriculture sector. The professionals involved were academicians, agricultural officers, farmer representatives, and business representatives of agricultural product sellers. The interview questions were designed to obtain expert opinions on the barriers that hinder farmers from using technology in agricultural activities. Raters were tasked with rating the degree of correlation between each obstacle using a scale ranging from 1 to 10. Scale values ranged from "Strongly Disagree" at 1 to "Strongly Agree" at 10.

The third phase is data analysis. The data have been analyzed using the DEMATEL framework. 20 data were collected from the agriculturist that has been involved in the agriculture sector for several years. All the data has been calculated using DEMATEL. In the fourth phase, numerous recommendations have been put forth to address the impediments hindering the implementation of digital technology in the agricultural domain. This recommendation is designed with the intention of mitigating the factors that contribute to the deceleration of progress in the agricultural domain. **Figure 1** shows a flowchart of methodology. All flows of several phases involved in carrying out this research can be seen in the figure below.

Steps used in DEMATEL framework are shown below.

Step 1. Creating the matrix of direct influence

The first step involves the creation of a Direct Relationship Matrix, where x_{ij}^k represents an integer score k assigned by an expert. This metric indicates the degree of impact that criterion i has on criterion j . The matrix A of dimension $n \times n$, as presented in Equation (1), the computation of household waste recycling scores involves the utilisation of an averaging process that incorporates the individual evaluations of three distinct experts, namely an academician, an industry specialist, and a government representative. **Table 1** presents the DEMATEL binary comparison scale that was utilised.

$$A = a_{jj} = \frac{1}{H} \sum_{k=1}^H X_{ij}^k \quad (1)$$

H : number of respondents.

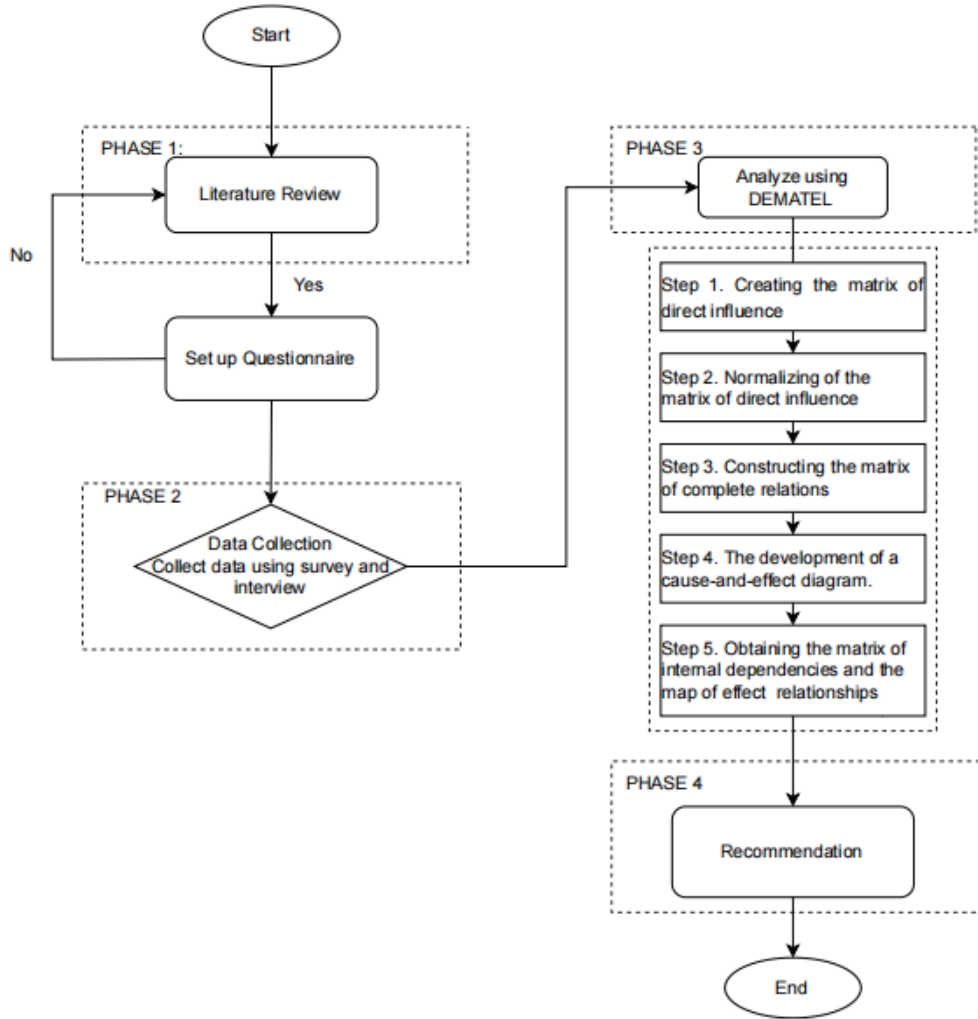


Figure 1: Flowchart of methodology

Table 1: Linguistic terms

Linguistic Terms	Influence Score
Extremely Unrelated	1
Very Unrelated	2
Unrelated	3
Slightly Unrelated	4
Moderately Unrelated	5
Moderately Related	6
Slightly Related	7
Related	8
Very Related	9
Extremely Related	10

Step 2. Normalising of the matrix of direct influence

Formulas (2) and (3) are used to get the normalised direct-relation matrix S from matrix A .

$$S = k \cdot A \quad (2)$$

$$k = \left(\frac{1}{\max_{1 \leq i \leq n} \sum_{j=i}^n [a_{ij}]}, \frac{1}{\max_{1 \leq j \leq n} \sum_{i=1}^n [a_{ij}]} \right), i, j \in (1, 2, \dots, n) \quad (3)$$

Step 3. Constructing the matrix of complete relations

After normalising the direct-relation matrix S , the total-relation matrix M is computed using the formula (4), where I denote the Identity Matrix:

$$M = S(I - S)^{-1} \quad (4)$$

Step 4. The development of a cause-and-effect diagram.

The utilisation of $C + R$ and $R - C$ is demonstrated in formulae (5) to (7) for matrix M , where R represents the sum of columns and C represents the sum of rows. Criteria that exhibit positive $R - C$ values exert a stronger influence on the remaining criteria. The term "dispatchers" is commonly used to refer to these individuals. Individuals with lower $R - C$ levels tend to be more susceptible to external influences. The entities are commonly denoted as "receivers." Conversely, the summation of R and C denotes the extent of correlation between one criterion and the rest.

$$M = [m_{ij}]_{n \times n} \quad i, j \in (1, 2, \dots, n) \quad (5)$$

$$R_i = \sum_{j=1}^n [m_{ij}]_{n \times 1} = [m_i]_{n \times 1} \quad (6)$$

$$C_i = \sum_{i=1}^n [m_{ij}]_{1 \times n} = [m_j]_{1 \times n} \quad (7)$$

Step 5. Obtaining the matrix of internal dependencies and the map of effect relationships

The dataset was mapped utilising the $(R + C, R - C)$. The parameter known as the threshold value is employed to denote the degree of influence present between a set of criteria.

3. Results and Discussion

This section provides an overview of the findings from applying the suggested DEMATEL framework to comprehend the connections among the barriers to technology adoption in the agricultural sector. A group of people with experience in agriculture as well as farmers came together to discuss how various components of the study's objective linked to one another.

Tables 3, 4 and 5 serve as the fundamental elements of the DEMATEL analysis, which is employed to assess the mutual relationship and significance of decision criteria. Table 3, referred to as the Matrix of Average Initial Direct Relationship, A, captures the degree of influence that citizens assign to gold between barriers B1 to B10. Table 4, denoted as the Relationship Matrix of Normalized Direct, S, normalizes this relationship to a standardized scale for the purpose of relative comparison. Lastly, Table 5, known as the Total Relationship Matrix M, amalgamates both the direct and indirect influences between the criteria, thereby offering a comprehensive viewpoint regarding its significance in the decision-making process.

Table 2: Average Initial Direct Relationship Matrix, A

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	0.0000	3.0500	4.6500	4.6500	4.4000	4.3500	4.5500	5.8500	4.6500	3.6000
B2	3.2000	0.0000	4.9500	3.5000	3.5500	4.4500	4.3000	4.5500	4.0000	3.2500
B3	3.8000	4.1500	0.0000	4.3000	4.4000	4.4500	4.4500	4.4500	5.4000	4.6500
B4	5.0000	3.3000	4.0000	0.0000	4.0500	4.3500	4.6500	3.3500	3.4000	3.7000
B5	4.2500	4.4500	3.6500	5.0000	0.0000	3.2500	5.2000	3.2000	3.6500	3.7000
B6	4.4500	4.8500	4.1000	4.5000	5.1500	0.0000	4.1500	4.3000	3.7500	4.4000
B7	3.8500	4.4000	3.9500	5.2500	4.7000	3.9000	0.0000	5.1000	4.4000	3.3500
B8	4.1500	3.8500	4.1000	4.1500	4.6000	3.0500	3.1500	0.0000	3.2500	4.7500
B9	4.4000	3.9000	3.5000	4.3000	3.7000	3.6500	3.7000	3.2500	0.0000	3.4000
B10	4.1000	3.4500	5.0000	5.1500	3.7000	2.8000	3.6500	3.2500	3.6000	0.0000

Table 3: Normalized Direct Correlation Matrix, S

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	0.0000	0.0762	0.1161	0.1161	0.1099	0.1086	0.1136	0.1461	0.1161	0.0899
B2	0.0799	0.0000	0.1236	0.0874	0.0886	0.1111	0.1074	0.1136	0.0999	0.0811
B3	0.0949	0.1036	0.0000	0.1074	0.1099	0.1111	0.1111	0.1111	0.1348	0.1161

B4	0.1248	0.0824	0.0999	0.0000	0.1011	0.1086	0.1161	0.0836	0.0849	0.0924
B5	0.1061	0.1111	0.0911	0.1248	0.0000	0.0811	0.1298	0.0799	0.0911	0.0924
B6	0.1111	0.1211	0.1024	0.1124	0.1286	0.0000	0.1036	0.1074	0.0936	0.1099
B7	0.0961	0.1099	0.0986	0.1311	0.1174	0.0974	0.0000	0.1273	0.1099	0.0836
B8	0.1036	0.0961	0.1024	0.1036	0.1149	0.0762	0.0787	0.0000	0.0811	0.1186
B9	0.1099	0.0974	0.0874	0.1074	0.0924	0.0911	0.0924	0.0811	0.0000	0.0849
B10	0.1024	0.0861	0.1248	0.1286	0.0924	0.0699	0.0911	0.0811	0.0899	0.0000

Table 4: Total Relationship Matrix, M

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	1.2078	1.2213	1.3261	1.4149	1.3356	1.2173	1.3270	1.3357	1.2765	1.2171
B2	1.1728	1.0475	1.2231	1.2731	1.2070	1.1196	1.2120	1.2012	1.1587	1.1079
B3	1.2991	1.2488	1.2276	1.4132	1.3397	1.2240	1.3302	1.3113	1.2968	1.2424
B4	1.2155	1.1278	1.2090	1.1992	1.2226	1.1225	1.2255	1.1826	1.1514	1.1211
B5	1.2102	1.1611	1.2124	1.3213	1.1405	1.1097	1.2474	1.1893	1.1662	1.1299
B6	1.3041	1.2554	1.3130	1.4085	1.3470	1.1170	1.3170	1.3011	1.2552	1.2297
B7	1.2691	1.2239	1.2855	1.3980	1.3141	1.1843	1.1990	1.2937	1.2455	1.1864
B8	1.1690	1.1111	1.1825	1.2614	1.2033	1.0680	1.1652	1.0745	1.1196	1.1161
B9	1.1422	1.0818	1.1370	1.2292	1.1522	1.0516	1.1438	1.1187	1.0133	1.0573
B10	1.1617	1.0963	1.1938	1.2745	1.1781	1.0578	1.1690	1.1436	1.1213	1.0034

Table 5: The development of cause and effect

Barriers	Ri	Ci	Ri + Ci	Ranking	Ri-Ci	Identify
B1 - Lack of skills	12.8792	12.1514	25.0307	2	0.7278	Cause
B2 - High cost	11.7230	11.5751	23.2980	8	0.1479	Cause
B3 - Low level of education	12.9331	12.3100	25.2431	1	0.6231	Cause
B4 - Lack of technology	11.7771	13.1934	24.9705	3	-1.4162	Effect
B5 - Limited locality	11.8881	12.4402	24.3282	5	-0.5521	Effect
B6 - Resistance to change	12.8480	11.2717	24.1196	6	1.5763	Cause
B7- Data privacy and security concerns	12.5995	12.3361	24.9356	4	0.2634	Cause
B8- Infrastructure and connectivity	11.4707	12.1516	23.6223	7	-0.6809	Effect
B9-Market access	11.1269	11.8043	22.9313	9	-0.6774	Effect
B10-Regulatory and policy	11.3995	11.4114	22.8109	10	-0.0118	Effect

From Table 5, B3 (Low level of education) exhibiting the greatest value of $Ri + Ci$ which is and B1 (Lack of Skills) in the second place with a value 25.0307. The two criteria have almost the same value, indicating that it is the main barrier to the use of digital technology in the country's agricultural industry. The following B4 (Lack of technology) and B7 (Data privacy and security concerns) have values 24.9705 and 24.9356. These 4 criteria are the main barriers thing in terms of implementing agriculture sector in Malaysia. With a score of 22.8109, B10 has the lowest effect out of all the criteria. Our ten criteria are split into two categories based on $(Ri - Ci)$. Values with $(Ri - Ci) > 0$ belong to the cause group. The other factors are immediately impacted by these criteria.

This causal diagram $Ri - Ci$ vs $Ri + Ci$ shows a cause-and-effect relationship between different obstacles. From identity, there is cause and effect shown cause and effect diagram. Values B1 (0.7278), B2 (0.1479), B3 (0.6231), B6 (1.5763) and B7 (0.2634) are positive values. So, this obstacle is the cause. Therefore, on this causal diagram, these eight obstacles are above the x-axis. In addition, the value of B4 (-1.4162), B5 (-0.5521), B8 (-0.6809), B9 (-0.6774) and B10 (-0.0118) are negative values. Therefore, this obstacle is the effect. So, on the diagram the causes of these three obstacles are below the x-axis.

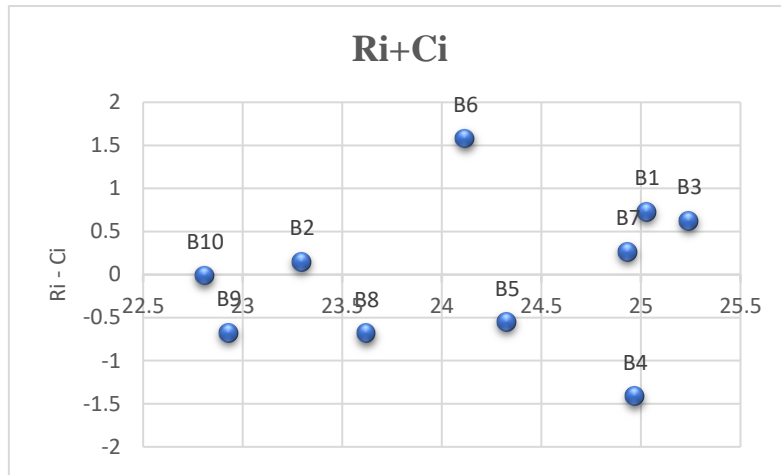


Figure 2: Causal Diagram of ($R_i - C_i$) vs ($R_i + C_i$)

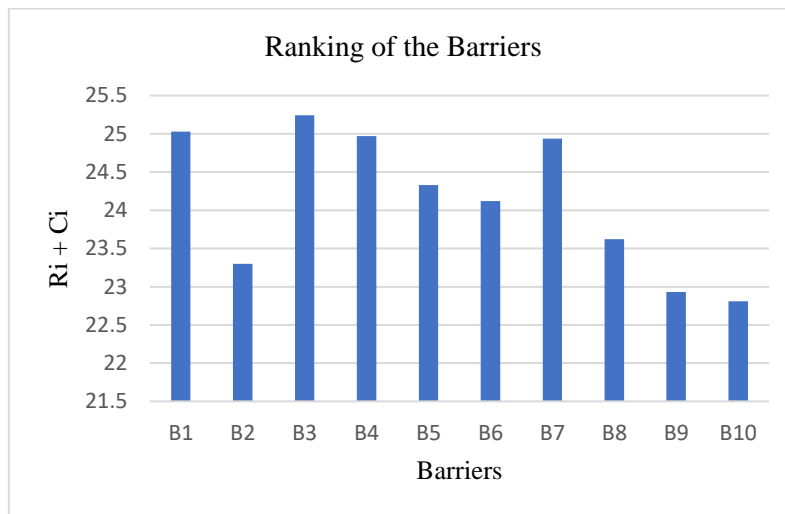


Figure 3: Ranking of Barriers

This figure 3 shows that the highest ranking from the barriers is B3, high cost. Ranking is based on R_i plus C_i values. B3 has the highest $R_i + C_i$ values which is 25.2431. This information indicates that B3, high cost, has the most relation with other criteria. Networking diagram for B1 until B10 can be seen in **Figure 4**.

As shown in **Figure 4**, the most barriers that have relationship between each other are B1, lack of skills, B3, low level of education, B6, resistance to change and B7, data privacy and security concerns. It means these barriers are the most obstacles for agriculturists. This can be seen in the situation of B1 affecting B3. The agriculturists will lack of skills because the technology is expensive, so they cannot practice using digital technology since it is not affordable to purchase the tools. For diagram B3, the example of networking between B3 and B7 can be seen in the situation of the aged farmers who think that digital technology is not important due to its price, so they think using traditional tools is better, and besides, the product will be of higher quality. An example of the network between B6 and B4 can be seen in the limited space conditions that will make it difficult for infrastructure to be developed rapidly and the last obstacle for them is they are not convinced that the change will have a positive impact and further advance their activities because they think data privacy is more important. The diagram of the total relation matrix can be seen in **Figure 5**.

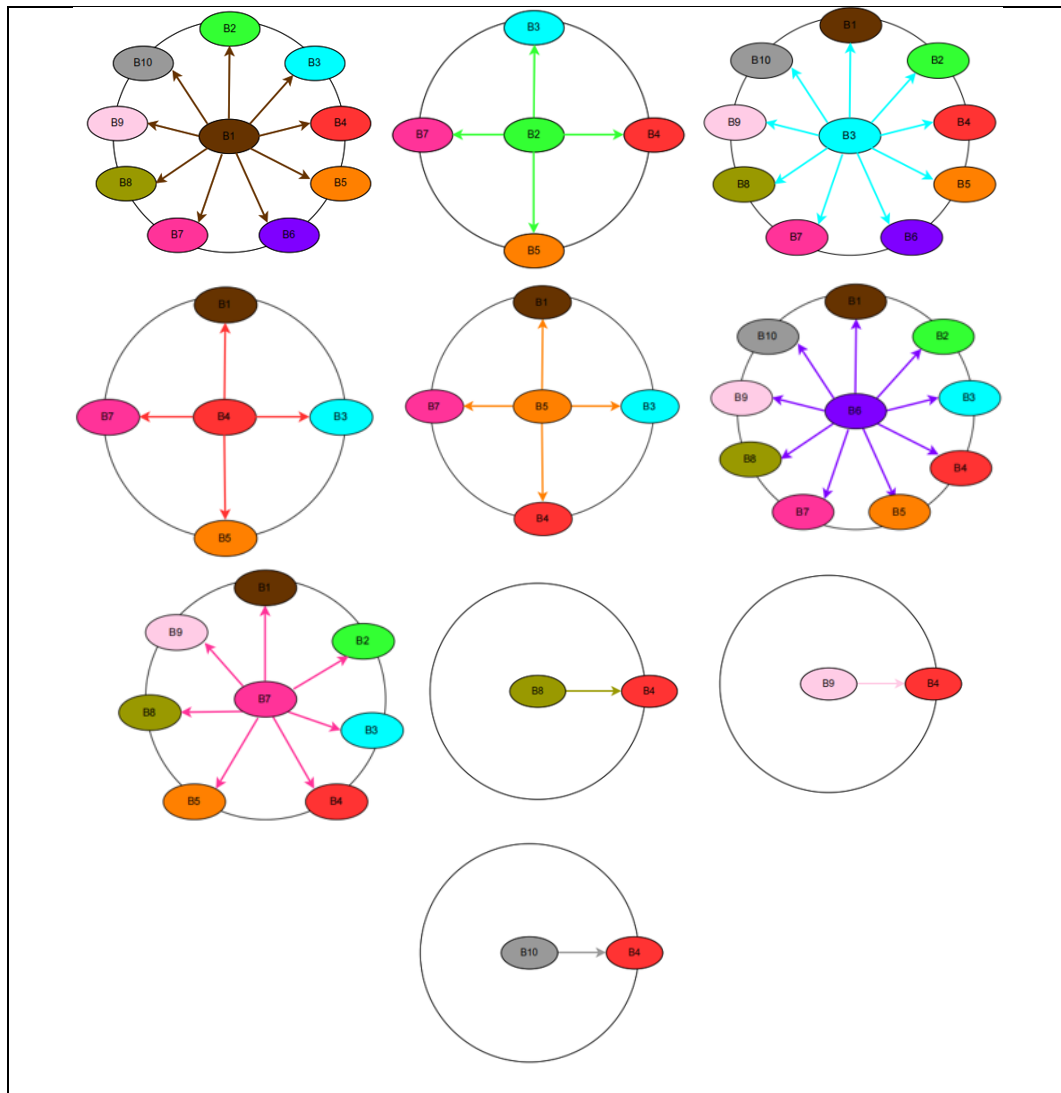


Figure 4: Networking diagram of each barrier

This influence diagram aids in **Figure 5** visualizing the cause-and-effect relationship among barriers to digital technology in agriculture sector. Insufficient availability of digital technology infrastructure and services, coupled with inadequate knowledge and understanding of the advantages of digital technology in agriculture. Based on the diagram, it shows all the obstacles that affect each other. From this figure, most obstacles have a relationship between them. Barriers that have more impact on the adoption of digitization technologies are B1, lack of skills, B3, high cost, and B6, infrastructure and connectivity. This matter also has an impact on other barriers, and there will be more and more obstacles that need to be faced in this matter.

Since lack of skills impacts many barriers, it shows that lack of skills is one of the barriers that has a big effect on agriculturists in using digital technology. The agriculturists will lack skills because the technology is expensive, so they cannot practice using digital technology since it is not affordable to purchase the tools. A few companies can buy sophisticated tools, but the barrier is the limited locality where there is no suitable space to place the technology tools. High cost is related to another nine barriers, which means this barrier is related to all the other barriers. The example of networking between high cost and infrastructure and connectivity can be seen in the situation of the aged farmers who think that digital technology is not important due to its price, so they think using traditional tools is better, and besides, the product will be of higher quality.

Infrastructure and connectivity have a big impact on this study since it has a lot of networking and other barriers. An example of the network between infrastructure and connectivity with limited locality can be seen in the limited space conditions that will make it difficult for infrastructure to be developed rapidly. It can be concluded that, from all the barriers listed, they will influence each other and create a big obstacle.

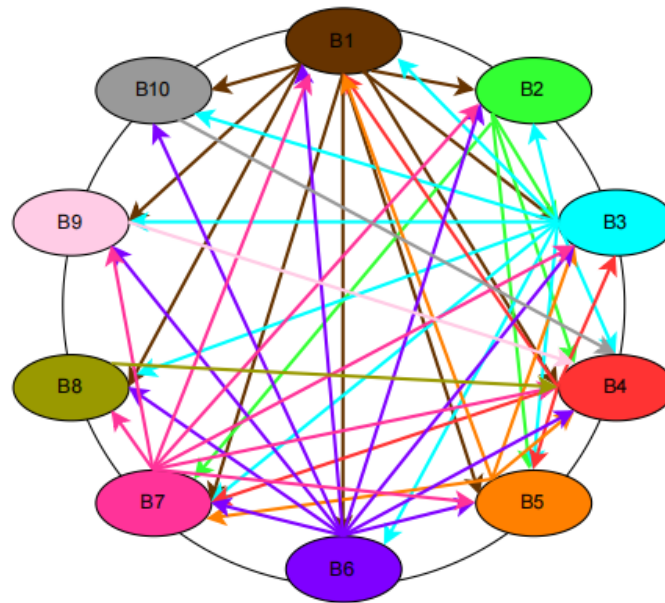


Figure 5: Diagram of the total relation matrix

4. Recommendation

Solidifying the array of barriers preventing the boost of Malaysia's agriculture sector through a comprehensive approach which combines the synergy of significant components could be the solution. Moreover, the setting up of financial aid mechanisms, as an example the subsidies, grants and the low interest loans is a necessity to solve the financial problem responsible for stopping farmers, especially those operating at a low level of the farm production businesses, from using digital technology devices in farming. In parallel to this, investing in capacity-building projects that train farmers and stakeholders in the use of digital technologies will aid to get the most value from these tools. Besides, the needed investments in rural infrastructure growth spanning from expansion of broadband internet and mobile network signal coverage are as well essential in providing disciplined digital access to every farmer in Malaysia.

Besides, the idea of promoting joint public-private partnerships (PPPs) does look promising because the two different parties will be able to provide and share the necessary tangible resources as well as expertise that speed up the process of digital solutions adaptation that are unique to Malaysia's agriculture sector. Strong frameworks need to be developed to handle privacy and security of data which both provides answers to privacy concerns and adds a layer of trust by their proper implementation. Furthermore, there are benefits linked to tailor-made solutions, extension services and specialized awareness programs that help raise awareness of the population, and hence the entrainment of digital innovations into agricultural activities.

Lastly, the making of reforms as policies that motivate innovation and set regulations to rise with sustainability standards cannot be ignored at any cost. Policy level can streamline the regulatory framework and provide regulatory incentives to innovating technology providers to create a favorable political environment that will be constructive for the wide use of digital technologies in agriculture. These combined measures can therefore be said to constitute the best response to surmounting digitalization related impediments and empowering the digital technology utilization to realize sustainable productivity, environmental conservation as well as resilience in Malaysia's agriculture sector with the hope of creating a progressive and technology rich future.

5. Conclusion

In conclusion, this study has analyzed the barriers of using digital technology among agriculturists in Malaysian using DEMATEL (Decision Making Trial and Evaluation Laboratory) approach. In this research project, scholarly literature was thoroughly examined, specialists were consulted, and the causal linkages between the impediments that were identified were closely examined. The findings highlight the major barriers to technology adoption in Malaysian agriculture sector, including lack of skills, high cost, and inadequate infrastructure and connectivity. This study has remarkable practical implications for agriculturists and policymakers. Policymakers can encourage the adoption of technology among agriculturist in the Malaysian agriculture sector by identifying and removing obstacles, such as improving infrastructure and connection. Additionally, the implementation of financial assistance mechanisms is necessary to mitigate the financial restrictions that farmers encounter when utilizing

technology in agriculture. The initiatives are crucial to ensuring that the Malaysian agriculture sector adopts digital technologies in agriculture. As a roadmap for future studies, we recommend, and at the same time, we will work on using these techniques presented in this work with many recently presented works, such as [28-37]

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