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Study of diet composition in sea cucumber intestines in Socah Waters, Bangkalan Regency

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Abstract. This paper aims to examine the understanding of the salt farmers regarding the Internet of Things (IoT) tool innovation and analyse their perceptions using five key innovation characteristics (Relative Advantage, Compatibility, Complexity, Trialability, and Observability). Internet of Things (IoT) has been considered as a key technology to assist in salt production improvements in Indonesia due to the continuing decline in production caused by climate change, especially in Madura Island. There was more than 75% decrease since 2019. In response, the Faculty of Agriculture at Trunojoyo University of Madura, Indonesia, in collaboration with Universiti Teknologi PETRONAS, Malaysia, conducted a socialization initiative for the salt farmer community in Pamekasan Madura on the importance of digitizing Internet of Things (IoT) technology. The socialization focused on an innovative product, the real-time monitoring tool 'Madura Smart Salt House (Mass),' specifically developed by UTP's students. This tool aids in monitoring humidity, salinity levels, and weather on salt farms. A total of 20 salt farmers participated in the socialization. Pre- and post-survey were conducted to address participant understanding in before and after socialization around tool's functions and operations, followed by a survey on five key innovation characteristics. The data was analysed using descriptive quantitative (Frequency distribution). The evaluation results indicated that the salt farmers gained an increased understanding of the importance of IoT in salt farming. However, elements such as complexity, trialability, and observability have caused some hesitation among the farmers in adopting the innovation. Despite this, the farmers are confident that the innovation can offer relative advantages and possess characteristics that can be adapted to the existing culture of their salt farming practices.

1 Introduction

Salt is an important commodity in Indonesia. Salt farms in Indonesia cover an area of 247.062.085 m2, with a total production of 627.022,72 tons [1]. The national salt requirements are generally categorized into industrial and non-industrial purposes, with the industrial use accounting 83% of the national requirement in 2022, increasing to 91% in 2023[2].

Despite its importance, salt sector requires support for its development. The Ministry of Marine Affairs and Fisheries (KKP) has reported annual salt production fluctuations with a declining trend, as shown in Table 1. Significant production declines have occurred in major producing regions such as East Java, central Java, and West Java. In particular, East Java experienced a decline of more than 75% from 2019 to 2022, making it the second largest producer after Central Java in 2022. Notably, 82.47% of East Java's salt production comes from Madura Island [3].

Pamekasan Regency is one of the major-salt-producing areas on Madura Island, covering an area of 958.70 ha, which has experienced fluctuating production in recent years [4]. Statistics show that salt production in Pamekasan regency reached 152,540 tons in 2019. However, following the national production trend, there was a drastic decrease in 2020 (approximately 75%), with production falling to just 38,836 tons. In 2021, production increased to 42,812 tons but declined again in 2022, reaching 37,528 tons.

Table 1. Salt Production in Major Producer Regions in Indonesia for 2019-2022 (TONS).

No	Province	2019	2020	2021	2022
1	East Java	917.931,89	398.927,05	358.878,05	211.800,32
2	Central Java	796.635,93	375.295,50	292.001,18	214.503,32
3	West Nusa Tenggara	168.637,68	156.965,75	115.261,79	119.036,17
4	West Java	445.726,69	41.489,20	83.527,03	65.554,34

Source: Statistic KKP, 2024 [1].

Fluctuations in salt production are often caused by the dependence of salt farming on uncontrollable environmental and weather conditions [5-7]. Weather has been a long-standing issue in salt production quality [2]. Currently, most salt production and weather observation are still conducted using conventional methods [8]. Enriko et al [9] attribute the lack of quality in locally produced salt to conventional methods and technological limitations. Therefore, innovations in

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weather observation methods need to be developed to enhance the stability of salt production. Internet of Things (IoT) has been considered as a key technology to assist in salt production improvements. It is crucial for farmers to utilize digital technology. Digital information technology can help predict weather accurately [10], allowing farmers to plan salt production activities better. Integrating digital technology will not only reduce dependence on unpredictable weather conditions but also help improve the productivity and quality of the salt produced. Kuswanto et al [11] also found that the Internet of Things (IoT) can effectively boost salt productivity in Indonesia and aid in meeting the growing demand for salt.

The importance of technological digitization in salt farming has prompted the Faculty of Agriculture at Trunojoyo University of Madura to collaborate with Universiti Teknologi Petronas, Malaysia, to conduct a socialization initiative on the digitization of technology, specifically the Internet of Things (IoT), in Pamekasan Regency. The socialization activities aimed to introduce new innovations to help address these issues. The IoT technology developed by Universiti Teknologi Petronas is a real-time monitoring tool that can track activities and analyze important parameters such as humidity, salinity levels, and weather conditions [12]. The IoT technology in this study is referred to as the Madura Smart Salt House (MaSS) Project.

The Madura Smart Salt House (MaSS) Project was developed as a comprehensive community engagement initiative aimed at addressing the specific challenges faced by salt farmers in Pamekasan, Madura Island, East Java, Indonesia. This initiative emerged from an in-depth analysis of the unique issues encountered by the farmers, including reliance on traditional production methods, variability in salt quality, and limited access to market resources. The MaSS project was tailored to prioritize education and aligned with SDG 9, focusing on Industry, Innovation, and Infrastructure. By integrating IoT technology in salt production, the project’s enhanced operational efficiency and monitoring systems, thereby demonstrating a commitment to quality education which is the core of SDG 4, Quality Education.

The development of the MaSS Project was grounded in a thorough assessment that included consultations, surveys, and direct engagement with the salt farming community. These assessments highlighted critical areas where the farmers needed support, particularly in adopting modern production methods including ensuring consistent monitoring of salt concentration, temperature and humidity. Recognizing these challenges, the project was designed to introduce tailored solutions that would effectively address these issues. The collaboration with UTM and the farmers themselves ensured that the interventions were grounded in both scientific knowledge and practical experience. This collaborative approach was essential in designing solutions that were both scientifically sound and culturally and economically feasible for the farmers.

However, it remains unclear whether salt farmers are prepared for this innovation. This is because salt farming on Madura Island is dominated by small-scale farmers with limited capabilities [13]. Furthermore, new innovations must also consider five key characteristics [14], [15]. First, Relative Advantage, which refers to the degree to which an innovation is perceived as better than the previous or conventional method. The higher the perceived advantage, the faster the innovation will be adopted. Second, Compatibility. The more compatible an innovation is with the values and norms of the users, the quicker it will be adopted. Third is Complexity where it highlights the perceived difficulty in adopting an innovation affects its acceptance; easier-to-adopt innovations will be accepted more quickly. Fourth, Trialability where innovations that can be tried on a limited basis will be more easily accepted. Fifth is Observability. Innovations whose results can be clearly observed by others will be adopted more rapidly.

Furthermore, introducing an innovation without understanding the social conditions and perceptions of potential users also carries a high risk of adoption failure [14, 16]. Therefore, the socialization initiative was not only to educate salt farmers about the importance of a smart integrated monitoring system through the Madura Smart Salt House (Mass) Project on their salt farms but also to understand the farmers' perspectives on the IoT innovation. This paper aims to examine the understanding of the salt farmer participants regarding the IoT tool innovation and analyse their perceptions using five key innovation characteristics (Relative Advantage, Compatibility, Complexity, Trialability, and Observability). This paper contributes to improving salt farmers understanding in the importance of IoT. The project's goal for the first phase of this project is to educate salt farmers on the fundamentals of Internet of Things (IoT) technology and its benefits to help improve their operations. This approach benefits farmers and strengthens the entire salt production community in the long-term.

2 Methods

2.1 Study area

The socialization activity and data collection on salt farmers' perceptions of this innovation were conducted at the Kedai Reka Cipta Garam, located in Majungan Village, Pademawu District, Pamekasan, Madura, on May 1, 2024. This location is a project site for salt development and innovation affiliated with Trunojoyo University of Madura, known as ‘Kedai Cipta Garam’ (Fig. 1). A total of 20 salt farmers was selected to participate the socialization based on recommendations from Kedai Reka Cipta Garam.

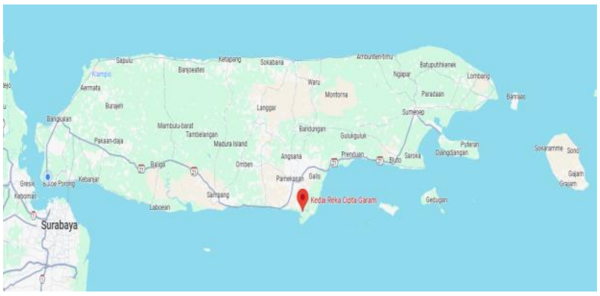

Fig. 1. Location of Kedai Reka Cipta Garam in Madura Island, Indonesia.

2.2 Data collection

The activities were carried out through the following series:

1. **Pre-activity Survey**. This was conducted to assess the farmers' initial understanding of the technology before the socialization activity. The respondents were given verbal consent during the data collection. In this pre-activity survey, questionnaires were distributed before the activity, accompanied by trained surveyors. Indicators used to assess the farmers' understanding before and after the socialization included 'Yes' and 'No' options. The elements evaluated were knowledge of the existence of IoT for the salt industry, the tool's functions, tool operations, data reading, and data comparison. The questionnaire was developed by drawing from existing literature and incorporating innovative elements from the tool.
2. **Socialization Session**. This session was conducted in three parts : lectures, discussions, and practical tool usage.
   a. Lectures were conducted to provide information to the respondents,
   b. Discussions took place among respondents, UTM, and UTP to share and exchange ideas about the innovation,
   c. The MaSSBot (prototype tool) demonstration showcased how the tool functions. The mechanism is explained below.

Fig. 2. IoT System (MaSSBot).

Source: Socialization Module of Mass tool [12].

In general, when the MaSSBot prototype is inserted into a salt solution, the two electrodes in it will sense the resistance between them. This value is crucial, as it can be used to calculate the salinity of the solution, which will help to determine the evaporation rate of the pond. The processor will calculate these values together with the input gathered from other sensors as well. MaSSBot consists of an Arduino R3 UNO processing unit, a DHT22 (temperature and humidity) sensor and two copper electrodes. It is a portable device that is chargeable and can be connected to a user's android device via Bluetooth or through a data cable. Both connection methods will allow the user to obtain readings from MaSSBot and upload the readings into cloud storage through the application that has been created alongside the prototype.

MaSSBot is equipped with Internet of Things (IoT) technology. It is made possible by the Bluetooth module, HC-05 that is installed into MaSSBot's hardware. The HC-05 Bluetooth module operates on Bluetooth version 2.0 + EDR (Enhanced Data Rate), which supports reliable and efficient wireless communication. It communicates with other devices using a serial communication interface, making it compatible with microcontrollers like Arduino UNO which is used in MaSSBot. The module typically supports standard baud rates like 9600 bps. Its communication range reaches 10 meters, which is sufficient for its current use.

In common Bluetooth modules, they follow the 'master' and 'slave' concept to distinguish the modules' ability and roles as a device. The HC-05 module was programmed to be a 'slave' in MaSSBot, where it can only carry out actions sent out by a 'master'. The user's handheld device such as a phone or tablet was set as the 'master', where this function can be accessed through a specialized application created to pair with MaSSBot.

Through this app, the 'master' can connect virtually with the 'slave' through Bluetooth and carry out readily set commands. This would include information retrieval from the 'slave'. After the sensors in MaSSBot receive input, it will be transformed into a 'string' by the Arduino Uno microcontroller that can be transmitted as an output. The 'string' –a group of phrases or a sentence– is transmitted by the HC-05 module to the user's device, the application programmed to display the long 'string' of information.

MaSSBot's primary function is to collect and store data of changes in the concentration of salt in salt ponds in a cloud storage system. The data received from the sensors is based on the surrounding temperature, humidity levels and the resistivity value between the electrodes. The values are displayed in the application and users are required to input another piece of information, that being wind speed, to calculate the final concentration of salt in the solution. When the user's device is connected to the internet and uploads the data via the application, the data will automatically be stored in a Google excel sheet where the sheet itself is saved in a Google Drive, a cloud storage system. The user can access the Google sheet via the application should they want to view back the collected data. When no data is detected or the data is not properly received, the blank spaces will be filled in with 'Data Receiving Error' instead.

As of now, the application does not include a user experience feedback feature in regards to MaSSBot and the application's performance. The current MaSSBot and its IoT features can only collect and store data. This data will convey the current concentration of the salt solution in the pond. This is crucial as the process for salt farming requires farmers to extract and move the salt from one pond to another following their level of concentration. The salt will be moved into specialized ponds suited for the intended concentration as it progresses through the evaporation process. If the farmer misses the time window and the concentration of salt is unsuitable to be moved to the next stage, it can affect the quality of the salt itself.

Considering that salt quality affects how it is priced [13], the lesser the amounts of impurities found in the salt, the higher the price. MaSSBot can help the farmers to know the optimal time window to move the salts into a different pond, allowing the salts to develop a high quality as it goes through the evaporation process. This will allow the farmers to sell their salt yield at a higher price. This can also create consistency in salt quality as the farmers can ensure that the salts are moved at the correct time based on the calculated concentration. This gives production stability.

The final phase of this project will require the development of this monitoring system. This system will be able to increase the productivity level of salt farming as it can help to speed up the evaporation process while also maintaining the salt quality throughout. This brings in higher salt yield per year, simultaneously increasing the farmer's income as well.

3. **Post-activity Survey**: This survey was conducted as an evaluation effort after the socialization activity. The elements of the questionnaire provided in the post-survey were the same as those used in the pre-survey ('Yes' and 'No' answer).

There are additional questions in the post-activity survey. Respondents were critically asked on their perception regarding MaSSBot innovation using five elements: relative advantage, compatibility, complexity, trialability, and observability. The farmers' perceptions of the socialization were measured using a five-point Likert Scale: 1 = Strongly Disagree (SD), 2 = Disagree (D), 3 = Neutral (N), 4 = Agree (A), and 5 = Strongly Agree (SA).

2.3 Data analysis

The data was analysed using descriptive quantitative (Frequency distribution). The key analysis involves farmers' characteristics, their understanding of pre and post activity, and their perceptions of the innovation tool based on five key characteristics (Relative Advantage, Compatibility, Complexity, Trialability, and Observability*)*. Descriptive analysis in this study involves examining samples/variables through frequency distributions, measures of central tendency, such as mean and median, and standard deviation [17, 18].

3 Results and discussion

3.1 Characteristics of socialization participants

The socialization activity was attended by 20 salt farmer participants. The characteristics of the participants are shown in Table 2. More than 50% of the participants are primary school graduates, and the majority are within the productive age range. According to the Central Bureau of Statistics (BPS), productive age is defined as under 64 years old [19]. The land owned by the participants is predominantly small-scale (less than 1 hectare). The percentage of participants with less than five years of experience and those with five to ten years of experience is nearly equal. The minimum experience among participants is 2 years, while the maximum is 24 years.

Table 2. Characteristics of participants in the socialization IoT Madura Smart Salt House (Mass) project.

Element	Category	Total	Percentage
Education	Elementary School	11	55%
	Junior High School	4	20%
	Senior High School	5	25%
	Total	**20**	**100%**
Age (years)	20-30	6	30%
	31-40	6	30%
	41-50	5	25%
	51-60	3	15%
	Total	**20**	**100%**
Area (Ha)	≤1 ha	11	55%
	>1 ha ≤ 2 ha	6	30%
	> 2 ha	3	15%
	Total	**20**	**100%**
Experience (years)	≤ 5 years	8	40%
	>5 years ≤ 10 years	7	35%
	> 10 years	5	25%
	Total	**20**	**100%**

3.2 Level of understanding of salt farmers before and after the socialization of the IoT Madura Smart Salt House (Mass) project

The socialization activity generally improved the participants' understanding of IoT digital technology in salt farming. Based on the pre- and post-activity survey results (Table 3), it was found that before the socialization activity, 75% of the participants felt they did not understand the importance of IoT in terms of its function, tool operation, and data reading. Additionally, around 80% of the participants did not understand the tool's working process and data comparison. Some salt farmers feel confident in their knowledge of IoT technology because they have already used it to monitor their salt farming. However, the IoT Mass project functions differently from the existing IoT technology they use. This technology detects temperature, humidity, salinity levels, and water turbidity, which will assist salt farmers in making decisions regarding the quality and quantity of salt produced [20]. As an example, Abdulrohiim et al [21] mentioned that higher salinity and temperature result in higher salt content.

Table 3. Level of understanding of salt farmers before and after the socialization of the IoT Madura Smart Salt House (Mass) project.

Elements	Before		After	
	Yes	No	Yes	No
Awareness of Internet of Things (IoT), an integrated monitoring system used to improve salt production processes	25%	75%	55%	45%
Understanding the functions and benefits of IoT	25%	75%	60%	40%
Understanding the operational processes of IoT in salt farming	20%	80%	65%	35%
Ability to operate IoT technology in salt farming	25%	75%	50%	50%
Ability to interpret data generated from the IoT salt system	25%	75%	60%	40%
Capability to compare real-time data produced by IoT with conditions required for salt production	20%	80%	55%	45%

After the socialization activity, there was an increase in participants' understanding in every aspect. The highest increase in understanding was in the aspect of the IoT working process, which rose by 45% (from 20% to 65%). This increased understanding is quite significant as some salt farmers mentioned that the operational process of the IoT Mass Project technology is simple and uncomplicated. The lowest increase was in the aspect of tool operation, which rose by 25% (from 25% to 50%). The number of devices used for socialization was only one unit, thus not all farmers had the opportunity to try the device. In other aspects, the increase was approximately 30-35% on average. Although there was a general increase in understanding, the achievement level did not reach the optimal value of 100%. This is understandable, as this was the first time the activity was conducted, and it has yet to provide a significant and comprehensive impact on understanding.

More efforts are required to enhance salt farmers' understanding of IoT innovation tools. Enhanced training and demonstrations are crucial. Some studies [22, 23] asserted that continuous and repeated efforts in socialization and outreach are essential to enhance farmers' comprehension of innovations. Additionally, hands-on demonstrations that can be closely observed are also required to improve their understanding and skills in utilizing technology. These practical sessions allow farmers to gain firsthand experience, thereby solidifying their knowledge and boosting their confidence in applying technological innovations.

3.3 Perception of participants on the (Iot) Madura Smart Salt House (Mass) innovation tool

The data on participants' perceptions of the characteristics of the introduced innovation is shown in Table 4 and Fig. 3. Overall, participants perceived that the MaSSBot tool could provide relative advantages and technological compatibility with the salt farming culture in Pamekasan. However, they still expressed doubts regarding the complexity, trialability, and observability of the tool. It is understood since the salt farmers participating in the socialization generally still use traditional production methods in observing natural and weather conditions visually. Comments from some participants included "interested in using IoT." However, there were also opinions such as "The socialization of this technology was too brief to fully understand the tool." Other participants mentioned that they gained additional knowledge, but its application would still require time.

Table 4. Perception of participants on the (Iot) Madura Smart Salt House (Mass) innovation tool for salt farming.

No	Element	Average
a	***Relative Advantage***	
1	The introduced IoT technology will help increase the quantity of salt production	4.2
2	The introduced IoT technology can provide work efficiency for salt farmers	4.15
3	The introduced IoT technology will help improve the quality of salt production	4.15
	Total rata-rata	**4.16**
b	**C*ompatibility***	
1	The introduced IoT technology can be applied using tools already owned by salt farmers	4.2
2	The introduced IoT technology is highly needed by salt farmers to address existing problems	4.2
3	The introduced IoT technology does not violate the cultural norms of your area	3.95
	Total average	4.11
c	***Complexity***	
1	The introduced IoT technology is easy to implement	3.45
2	The introduced IoT technology has features/methods that are easy to understand.	3.3
3	The introduced IoT technology does not require a large or complex amount of equipment	3.25
	Total average	**3.33**
d	**Trialability**	
1	Salt farmers can trial the use of IoT without assistance.	2.85
2	The use of IoT in salt farming does not require significant costs	2.9
3	The use of IoT does not require specific skills or expertise	3.15
	Total average	**2.9**
e	**Observability**	
1	Salt farmers can directly see the results of IoT usage	3.25
2	Salt farmers can see the difference between before and after the implementation of IoT	3.6
	Total average	**3.43**

Note: 1 = Strongly Disagree (SD), 2 = Disagree (D), 3 = Neutral (N), 4 = Agree (A), and 5 = Strongly Agree (SA).

The fact that 55% of the socialization participants in this study are primary school graduates is a key concern. Higher education levels enable potential adopters to understand the advantages of innovation and its associated risks [15]. Additionally, although the use and access to smartphones are now common, age also influences the adoption of innovations [16]. In general,

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age influences physical condition, learning ability, and the level of risk-taking. As age increases, there tends to be a greater reluctance to adopt new innovations [23, 25]. However, there has been a successful example of IoT implementation in salt production, where farmers reported 89.8% satisfaction level with the monitoring and control system applied to their salt ponds for water level and salinity management [24].

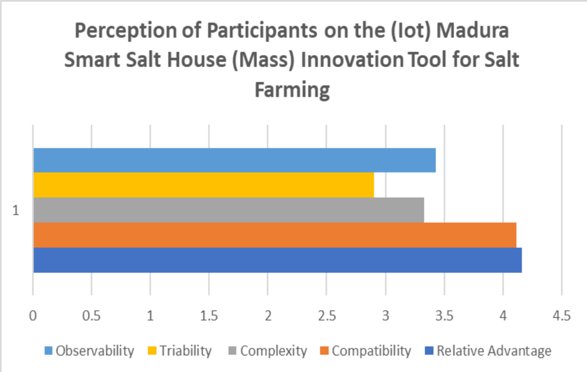

Fig. 3. Participants' perception on the IoT Smart Salt House (Mass) innovation tool.

Further intervention is needed to build confidence and observability. Socialization and demonstrations serve as initial stages to introduce the importance of IoT technology. While these efforts can help familiarize farmers with the concept, additional interventions are necessary for effective adoption. Farmers who are younger and more educated tend to grasp innovations more readily and are likely to adopt new practices more effectively. Additionally, extending the duration of demonstrations and trials, along with providing ongoing mentoring, becomes crucial. These extended engagements allow farmers to deepen their understanding and proficiency in utilizing IoT technologies, facilitating smoother integration into their practices. These efforts will help reduce their hesitations regarding trialability, complexity, and observability. In the future, farmers' intentions to adopt IoT technology need to be translated into actual behavior, and it is essential to align their intentions with their actions [23].

In general, the activities of socialization and data collection are shown in the Fig. 4.

The Madura Smart Salt House (MaSS) project is not final and planned to be carried out in multiple phases. The final goal is to develop an IoT device that can respond to the changes in the environment of the salt pond to ensure that it is always conducive for salt evaporation. This would mean the development of a monitoring system that can sense the relevant parameters such as temperature, humidity, wind speed and solar irradiation –factors affecting evaporation– and create a response to the changes that occur. For example, if there is a drop in temperature in the surroundings of the salt pond, the monitoring system will detect this change and command the thermostat to increase the temperature. This system will ensure that salt will be produced at an optimal level, which combats evaporation reduction during nighttime, when the sun is not available to promote evaporation and speed up the process.

Fig. 4. Data Collection process (pre- dan post- activity survey).

Fig. 5. Discussion session with UTP Malaysia participants and salt farmers.

Fig. 6. Trial of MaSS sensor device.

Fig. 7. All participants of the collaboration service activity between the Faculty of Agriculture at Trunojoyo University of Madura and Universiti Teknologi Petronas Malaysia.

Future phases will also expand on data collection, add new features, and enhance production rates. This project sets a foundation for ongoing collaboration with future teams and builds trust with the local community. Training locals in IoT usage is crucial for self-sufficiency, with support from UTM for complex issues. An increase in productivity and efficiency was observed as the farmers adopt improved salt harvesting and brine management techniques. This is expected to enable them to produce more salt in a shorter period, reducing labor costs and increasing overall efficiency. This will result in higher-quality salt with fewer impurities, allowing the farmers to demand better prices in the market and access new market opportunities.

Overall, the MaSS Project represents a comprehensive and well-thought-out initiative that addresses the critical needs of salt farmers in Pamekasan. By enhancing productivity, improving the quality of salt, and promoting sustainable practices, the project could transform the salt farming sector and improve the livelihoods of the farming community. Through its participatory approach and tailored interventions, the project served as a model for community engagement and development in similar contexts, demonstrating the effectiveness of collaborative and context-sensitive solutions in addressing local challenges.

4 Conclusion

The fluctuating and generally declining salt production necessitates improvements in farming activities. Natural conditions and weather are the primary factors causing production uncertainty, making digital technology innovations crucial to addressing this issue. The socialization of the importance of the Internet of Things (IoT), conducted by the Faculty of Agriculture at Trunojoyo University of Madura in collaboration with Universiti Teknologi Petronas Malaysia, showed increased participant understanding. Further mentoring stages are needed to optimize understanding of IoT in salt farming, reaching a point where farmers are ready to accept and implement the innovation.

The limitations in this study should be addressed in future research. Expanding the scale of respondents and exploring other salt farming areas could provide more comprehensive results, enhancing understanding of salt farmers' perceptions towards IoT innovation. Additionally, exploring government policies related to IoT is critical to aligning them with the needs for salt farming improvements.

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