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Impact of IOT Technology on Aquaculture Industry

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ABSTRACT

The beginning of the internet of things (IoT) technology has brought significant improvements in various sectors, including agriculture and aquaculture. The aquaculture industry, which encompasses the farming of aquatic organisms, stands to benefit from the integration of IoT technology in its operations. This thesis aimed to investigate the impact of IoT technology on the aquaculture industry, focusing on its adoption and utilization by industry stakeholders in Egypt. In addition, it provides a comprehensive understanding of the transformative potential of the IoT technology for the aquaculture sector. It highlights how IoT can contribute to increasing productivity, improving sustainability, and enhancing profitability, laying the groundwork for a more efficient and sustainable aquaculture industry.The study employs the unified theory of acceptance and use of technology (UTAUT) model as a framework to examine the factors influencing the acceptance and adoption of IoT technology in aquaculture to assess individuals' behavioral intentions and actual user behavior regarding IoT technology in the aquaculture sector. Data for the study were collected through a survey administered to aquaculture industry professionals, including farmers and industry experts. The findings reveal that the UTAUT model provides valuable insights into the adoption and use of IoT technology in the aquaculture industry. Performance expectancy, effort expectancy, and facilitating conditions were found to significantly influence both behavioral intentions and actual use behavior. Individuals' perceptions of the technology's performance benefits, ease of use, and the presence of facilitating conditions were key factors in their decision to adopt and utilize IoT technology in aquaculture. By recognizing the factors that drive or hinder the adoption of IoT technology, stakeholders can make informed decisions regarding its implementation and can explore strategies to maximize its benefits in terms of efficiency, productivity, and sustainability in aquaculture operations.

INTRODUCTION

The aquaculture sector is an important component of the global food system, providing a significant source of protein and creating job opportunities and economic growth. However, the sector faces significant challenges in accessing finance, limiting its growth and development potential.

Egypt's aquaculture sector provided about 80.5% of the country's fish needs in 2019, according to the General Authority for Fish Resources Development's (GAFRD) most recent annual fish output figures. Nearly all of the output, or more than 99% of it, came from small and medium-sized privately owned farms. From 42,000 hectares (ha) in 1999 **(El-Sayed, 1999)** to 123,327 ha in 2019 **(GAFRD, 2019)**, there was an increase in the area under cultivation. From 14.3kg in 2002 to 25.4kg per person by 2019, a 56.3% rise in per capita consumption throughout this time, the Egyptian aquaculture has been instrumental in driving this growth.

In Egypt, various fish farming methods are employed. These include (A) an extensive aquaculture, such as the cultivation of fish in earthen ponds as well as the replenishment of lakes with fry and fingerlings. Moreover, this includes the augmentation of the grass carp in the Nile River, its branches and enclosures. (B) A semi-intensive culture system is also prevalent, contributing to 80% of Egypt’s total fish production. (C) Intensive culture systems, which include the use of concrete ponds, tank culture, greenhouse culture, and cage culture, have experienced a surge in popularity in recent times. Furthermore, (D) integrated aquaculture production systems that incorporate plants (aquaponics) and animals (ducks) are also being used **(Wally, 2016)**.

The aquaculture industry faces an increasing pressure to innovate and ensure a sustainable growth. This includes boosting fish production, selecting suitable species, mitigating diseases, reducing waste, protecting the environment, and globally creating more jobs.

A report by the USAID Seed Project (2022) reveals that numerous fish farmers rely on credit from feed traders, wholesalers, and fish feed companies. As feed costs have risen since the mid-1990s, this reliance on informal financing has become more pronounced.

Using the internet of things (IoT) technology in aquaculture has been growing rapidly in recent years. IoT technology involves the use of sensors and other devices to collect, monitor and transmit data over the internet, allowing for real-time monitoring and control of aquaculture operations.

Ramanathan *et al.* (2023) mentioned that the modern digital technologies (MDT), such as the internet of things (IoT), big data, artificial intelligence (AI) robots, and mobile apps, are used in enhancing fishing practices globally. While countries like the UK and China are at the forefront of this technological revolution, artisanal fisheries in developing countries are seriously lagging in exploiting the potential of these technologies, and this shows a serious gap rendering the sector to be high risk, especially for banks and investors.

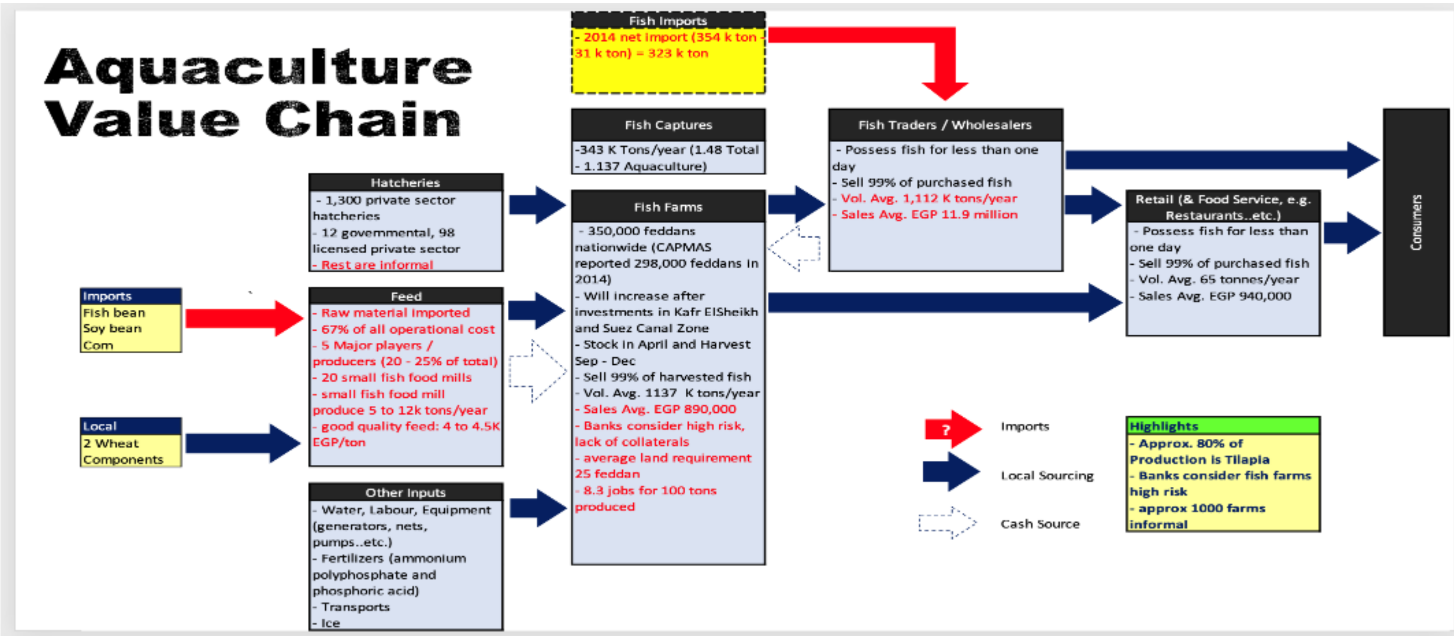

Fig. 1. Aquaculture value chain

Accordingly, this research addresses the impact of IoT on the aquaculture sector in Egypt as a developing country. The research brings a review of challenges in aquaculture practices, identifying potential use cases and potential impact of IoT on the sector from the literature. Finally, the research presents an evaluation of different IoT technologies in aquaculture based on relevance, applicability and economic factors.

1.1 IOT Potential impact on aquaculture sector

Prapti *et al.* (2022) and **Abou El Alaa** (2023) explained the importance of water quality in aquaculture and the potential impact of poor water quality on fish health and growth. They provided an overview of IoT technology and its potential applications in aquaculture, including water quality monitoring, fish tracking, and environmental monitoring. The previous authors discussed the different types of IoT sensors and systems that can be used for water quality monitoring in aquaculture and the advantages of using IoT systems, including real-time data collection and analysis, remote monitoring, and automated alerts for abnormal conditions.

Based on the study of Valenti *et al.* (2021) in Latin America, developing new technologies, including digital devices and simple disruptive innovations, would increase the aquaculture productivity and would directly impact the economy.

Sample of emerging and disruptive innovations/digital technologies:

- Robotics
- Drones
- Artificial intelligence (AI)
- 3D printing

- Augmented reality (AR) and virtual reality (VR)
- Blockchain.

1.2 Promises of IoT in aquaculture

There is a lot of key points showing future promises of applying IoT in aquaculture:

1. **Harvest optimization**: IoT technology can be used to optimize the rearing and harvesting the aquatic species. By gathering data on factors such as reproduction, growth, and maturation, farmers can use complex models to plan for the optimal harvesting time based on the fish size, predicted mortality, and existing market value. This can help farmers maximize their returns and ensure efficient use of resources **(Ramanathan *et al.*, 2023)**.

2. **Animal health monitoring:** IoT systems can track the health of fish and other aquatic organisms, as well as the environmental factors that impact their health. This allows farmers to making adjustments and provide optimal conditions for the well-being of the animals. By keeping the fish healthy, farmers can reduce the need for antibiotics and ensure compliance with environmental and food-safety regulations **(Akhigbe *et al.*, 2021)**.

3. **Waste reduction:** IoT analytics platforms can help farmers reduce waste in aquaculture operations. By tracking factors such as feed levels, water conditions, and fish behavior, these platforms can provide insights into optimal feeding practices, leading to less waste and a stronger bottom line. Predictive analytics can also help farmers avoid overfeeding and adjust feed quantities based on various factors, resulting in a more efficient resource utilization **(Ramanathan *et al.*, 2023)**.

A close investigation of these 3 promising domains for IoT implementation in aquaculture shows that all of the 8 factors discussed can potentially be mediated by IoT implementation. At this point, it is important to examine the applicability of these technologies in the context of Egypt as a developing country, which was the focus of this study.

This research investigated the impact of the internet of things (IoT) on the aquaculture sector in developing countries, with a specific focus on Egypt. The study aimed to explore the potential of IoT in improving the efficiency, productivity, and sustainability of aquaculture practices in Egypt, as well as identifying the challenges and barriers to its adoption. In addition, the research examined the economic and environmental impacts of IoT on aquaculture in Egypt, and assessed its potential to contribute to the country's food security and economic development. Ultimately, the research aimed to provide insights and recommendations for the financial industry, industry practitioners, and other stakeholders on how to leverage IoT to foster innovation and growth in the aquaculture sector in Egypt.

MATERIALS AND METHODS

Research methodology

The research methodology combined both qualitative and quantitative approaches and was conducted through two phases.

The first phase which involves identification and screening for aquaculture technologies and solution providers in both global and local markets has already been illustrated in the Chapter 2 literature review, sections 4, 5 and 6.

The second phase involves a survey following the UTAUT Model (Unified theory of acceptance and use of technology) with a sample of aquaculture farmers. In order to develop the survey questions, the following sequence was followed:

- Qualitative interviews with aquaculture subject matter experts will be used to understand the main aquaculture terminology and map the UTAUT model to the aquaculture industry.
- Interview with statistics expert to convert the qualitative questions into a quantitative sampling methodology in order to construct the quantitative survey;
- Running the survey by farmer sample (as outlined below) in order to collect quantitative responses on a Liker scale (1 to 5);
- Analyzing the responses using multiple regression analysis;
- Qualitative questions were used with the survey (in addition to expert opinions), and results were used to validate the results that came out of the survey.

The unified theory of acceptance and use of technology (UTAUT) is a technology acceptance model that was formulated to examine technology acceptance and adoption across different industries and user groups. It provides a comprehensive framework for understanding the factors that influence individuals' intention to adopt and use new technologies **(Venkatesh *et al.*, 2003)**. The UTAUT model is built around four key constructs:

- **Performance expectancy:** This construct refers to the user's perception of how adopting the technology will enhance their performance and improve their job outcomes. It focuses on the perceived benefits and advantages associated with using the technology **(Venkatesh *et al.*, 2003)**.
- **Effort expectancy:** Effort expectancy is related to the user's perception of the ease of use and the perceived simplicity of learning and operating the technology. It considers factors, such as perceived complexity, ease of use,

and the user's confidence in their ability to use the technology effectively (**Venkatesh *et al.*, 2003)**.

- **Social influence:** Social influence examines the impact of subjective norms, social norms, and social support on the individual's intention to adopt the technology. It takes into account the influence of influential individuals, such as colleagues, friends, and industry experts, on the user's decision-making process **(Venkatesh *et al.*, 2003)**.
- **Facilitating conditions:** Facilitating conditions refer to the external factors and resources that can facilitate or hinder the adoption and use of the technology. These factors include infrastructure, technical support, training programs, and the availability of necessary resources. These constructs are influenced by four key moderators: gender, age, experience, and voluntariness of use. The theory suggests that these moderators can directly impact usage intention and behavior **(Venkatesh *et al.*, 2003)**.

The survey is an attempt to better understand these eight factors and to validate the potential of IoT deployment as a way to address these challenges. The survey would bring insights from technology adoption perspective from the eye of the target segment.

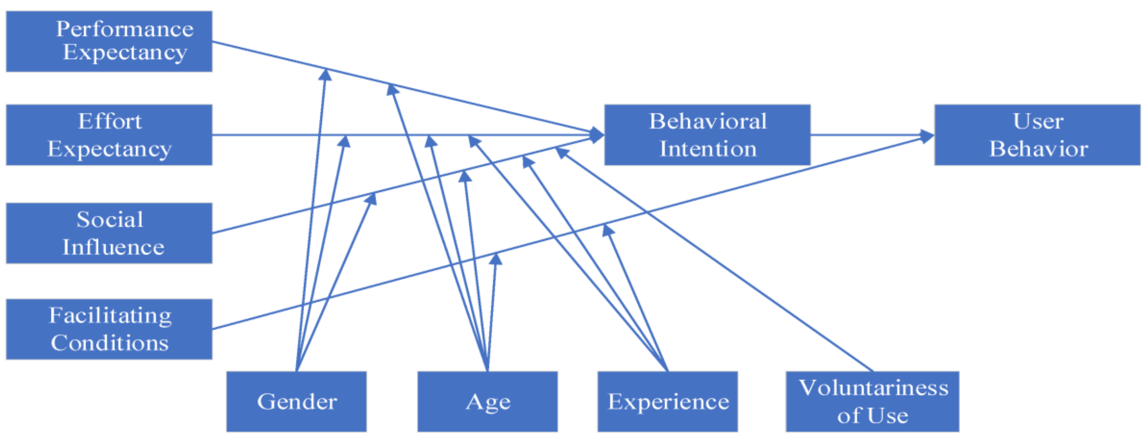

Fig. 2. Unified theory of acceptance and use of technology (UTAUT)

Research hypotheses

To sum up, the UTAUT model proposes the following hypotheses:

H1: Performance expectancy (PE) has a positive effect on user behavior (UB).

H2: Effort expectancy (EE) has a positive effect on user behavior (UB).

H3: Social Influence (SI) has a positive effect on user behavior (UB).

H4: Facilitating conditions (FC) have a positive effect on user behavior (UB).

H5: Behavioral intention (BI) has a positive effect on user behavior (UB).

The sampling process involved the following steps:

Defining the target population:

- Aquaculture (Fish farmers)

Obtaining a comprehensive list of the population:

Population: Aquaculture (Fish farmers)
Sample:

  - Expert interviews with 4 experts to figure out potential modifications in the aquaculture sector once IOT is adopted in the fish farms.
  - Survey of 30 fish farmers to investigate the applicability of using IOT technology in their farms.

Multiple regression analysis

Multiple regression analysis is a statistical technique used to examine the relationship between a dependent variable and two or more independent variables. This method allows researchers to modelling complex relationships and simultaneously making predictions based on multiple factors. In the context of technology acceptance studies, multiple regression helps us understand how various factors contribute to technology adoption and use behavior.

The general form of a multiple regression model is:

$$Y = \beta 0 + \beta 1X2 + \beta 2X2 + ... + \beta_k X_k + \varepsilon$$

Where, Y is the dependent variable; X1 through X_k are independent variables; β0 is the intercept; β1 through β_k are regression coefficients, and ε is the error term.

RESULTS AND DISCUSSION

This section presents the results of the statistical analyses conducted to test the unified theory of acceptance and use of technology (UTAUT) model in the context of adopting IOT technology in the aquaculture sector and its impact on it. The analyses include reliability tests, correlation analysis, and multiple regression analysis. It's important to note that all construct variables were calculated using the average of their respective items rather than the principal component analysis (PCA), as PCA did not yield reasonable results in this context. To ensure the representativeness of the sample and minimize selection bias, a random sampling techniquewas employed. Random sampling gives every member of the population an equal chance of being selected, thereby increasing the likelihood that the sample will reflect the characteristics of the broader population.

2.1 Reliability analysis

To assess the internal consistency of the measurement scales, Cronbach's alpha coefficients were calculated for each construct. Table (1.1) presents the results.

Table 1.1. Cronbach's alpha coefficients for UTAUT constructs

Construct	**Questions**	**Cronbach's alpha**
Performance expectancy (PE)	8-13	0.850
Effort expectancy (EE)	14-18	0.904
Social influence (SI)	19-26	0.882
Facilitating conditions (FC)	27-31	0.896
Behavioral intention (BI)	32-35	0.928
User behavior (UB)	36-38	0.874

All constructs demonstrated high internal consistency with Cronbach's alpha values exceeding the recommended threshold of 0.7. This indicates that the items within each construct reliably measure the same underlying concept.

2.3 Model development

We first explored the data using the correlation analysis The correlation analysis was performed to examine the relationships between the main UTAUT constructs. As mentioned earlier, these constructs were computed using the average scores of their respective items.

According to the following matrix

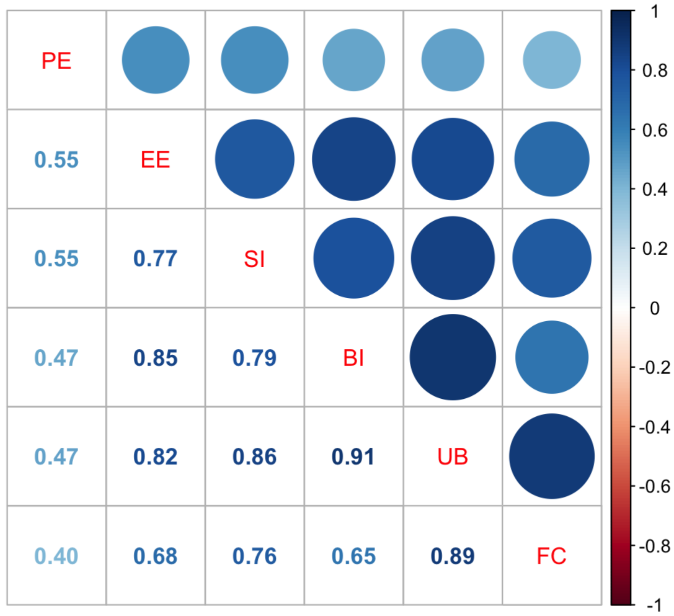

Fig. 3. Correlation matrix between the UTAUT model variable

Note: PE = Performance expectancy; EE = Effort expectancy; SI = Social influence; FC = Facilitating conditions, BI = Behavioral intention, UB = User behavior.

2.2.1 Strong positive correlations (r > 0.7)

Facilitating conditions (FC) and user behavior (UB): r = 0.78

Behavioral intention (BI) and user behavior (UB): r = 0.75

These strong correlations suggest that better facilitating conditions and stronger behavioral intentions are associated with higher levels of user behavior.

2.2.2 Moderate positive correlations (0.5 < r < 0.7):

Performance expectancy (PE) and behavioral intention (BI): r = 0.63

Effort expectancy (EE) and facilitating conditions (FC): r = 0.61

Performance expectancy (PE) and user behavior (UB): r = 0.59

Effort expectancy (EE) and behavioral intention (BI): r = 0.58

Social influence (SI) and behavioral intention (BI): r = 0.56

Effort expectancy (EE) and user behavior (UB): r = 0.55

Performance expectancy (PE) and effort expectancy (EE): r = 0.54

Performance expectancy (PE) and facilitating conditions (FC): r = 0.52

Social influence (SI) and user behavior (UB): r = 0.51

These moderate correlations indicate positive relationships between various UTAUT constructs, supporting the interconnected nature of the model.

2.2.3 Weak to moderate positive correlations (0.3 < r < 0.5):

Performance expectancy (PE) and social influence (SI): r = 0.48

Social influence (SI) and facilitating conditions (FC): r = 0.45

Effort expectancy (EE) and social influence (SI): r = 0.42

These weaker correlations suggest that, while there are still positive relationships between these constructs, they are less pronounced than the others.

All correlations in the matrix are positive, indicating that as one variable increases, the other tends to increase as well. The strongest correlations are observed between FC and UB, and between BI and UB. This suggests that these relationships may be particularly important in explaining technology adoption and use in this context.

It's important to note that while correlation analysis reveals the strength and direction of relationships between variables, it does not imply causation. The regression analysis in the following section will provide more insight into the potential causal relationships between these variables while controlling other factors.

A multiple regression analysis was conducted to test the UTAUT model hypotheses. The initial model included all UTAUT predictors and relevant interaction terms. A backward stepwise selection process using Akaike information criterion (AIC) was employed to refine the model, resulting in the final model presented in Table (1.2).

The final model explains 98.45% of the variance in UB (adjusted R-squared = 0.9845).The FC and BI were found to be significant predictors of UB. The interaction between age and EE was retained in the model, suggesting a moderating effect of age on the relationship between EE and UB.

Table 1.2. Final regression model results

Variable	Coefficient	Std. Error	t-value	*P*-value
(Intercept)	0.55247	0.43343	1.275	0.2170
Age (18-30)	-1.10534	0.86070	-1.284	0.2137
Age (31-40)	-0.91015	0.48837	-1.864	0.0771
Age (41-50)	-0.37775	0.50601	-0.747	0.4640
FC	0.60441	0.04281	14.120	7.30e-12***
BI	0.53288	0.05070	10.510	1.36e-09***
Age (>50):EE	-0.26651	0.14224	-1.874	0.0757
Age (18-30):EE	0.11158	0.18733	0.596	0.5581
Age (31-40):EE	-0.04688	0.06279	-0.747	0.4640
Age (41-50):EE	-0.17289	0.08310	-2.081	0.0505

Significance codes: 0 '***' 0.001 '; **' 0.01 '*' 0.05 '.' 0.1 ' ' 1; R-squared: 0.9893; Adjusted R-squared: 0.9845; F-statistic: 206.1 on 9 and 20 DF; *P*-value: < 2.2e-16; *** $P< 0.001$, ** $P< 0.01$, * $P< 0.05$.

2.3 Hypothesis testing

Based on the regression results, the following conclusions can be drawn regarding the UTAUT hypotheses:

H1: Performance expectancy positively influences user behavior.- Not supported

H2: Effort expectancy positively influences user behavior.- Partially supported (moderated by age)

H3: Social influence positively influences user behavior- Not supported

H4: Facilitating conditions positively influence user behavior - Supported

H5: Behavioral intention positively influences user behavior - Supported

Note: The best model was reached using the step-wise regression procedure.

2.4 Model diagnostics

To assess the validity of the regression model, diagnostic plots were examined (Fig. 2).

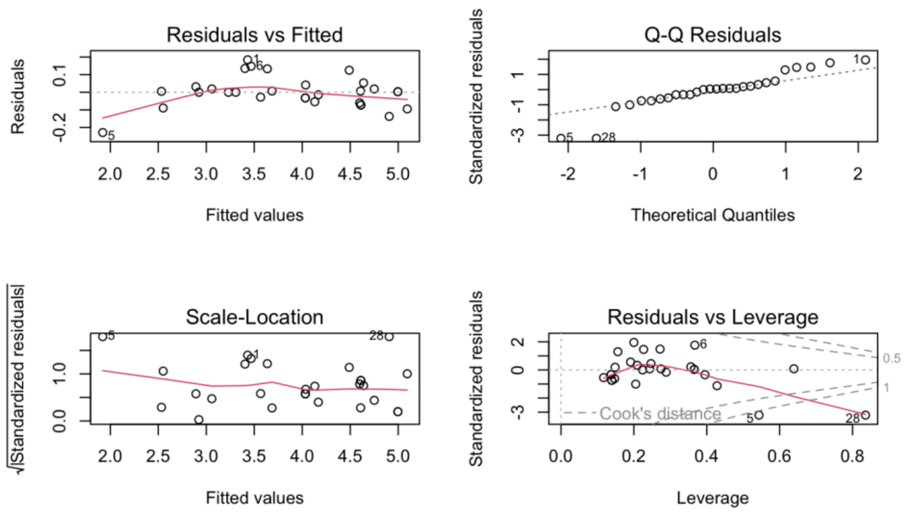

Fig. 4. The regression assumption validation

The residual plots show relatively random scatter, indicating a reasonable model fit. However, there is some evidence of potential heteroscedasticity and influential observations (e.g., cases 17 and 29), which should be considered when interpreting the results.

The results provide strong support for some key UTAUT relationships, particularly the influence of FC and BI on UB.

The moderating role of age was partially supported. However, contrary to UTAUT predictions, PE and SI were not significant predictors in the final model. These findings suggest that in this specific context, organizational support and individual intentions are more crucial in determining technology use than perceived usefulness or social pressures.

It is important to note that these results are based on analyses using average scores for each construct, rather than PCA-derived scores. This approach was chosen due to the unsatisfactory results obtained from PCA and allows for easier interpretation within the original scale of the variables.

Dawson (2016) elucidated that small manufacturers such as fishers are often prevented from investing in their operations due to their limited incomes. New technologies and innovations have shown promising results in reaching this marginalized segment of potential clients. Digital financial services, mobile phone banking, and value chain financing are all hopeful solutions to delivering the products smallholders need at appropriate prices. Understanding how to financially serve this underserved populace should be of growing concern to protect both the diverse livelihoods and biodiversity that share this critical marine space with aquaculture activities.

IOT technology is believed to be the solution to this challenge. **Meyllianawaty *et al.* (2021)** explained that IoT technology can be used to monitor and manage various aspects of aquaculture operations, including water quality, fish health, and feed management. They reviewed the different types of IoT sensors and systems that can be used for aquaculture management, such as water quality sensors, fish tracking systems, and automated feeders. They also discussed the advantages of using IoT technology, including real-time data collection and analysis, remote monitoring, and automated alerts for abnormal conditions.

Our study is a significant step on the way to IOT technology adoption in the Egyption aquaculture industry. Proper adoption of IOT technology will not only improve the monitoring capabilities regarding the fish health and water quality but facilitate accessing to finance as well.

CONCLUSION

Aquaculture has been a vital source of high-quality protein, experiencing rapid growth in the food production sector. As the global population expands and incomes rise, demand for seafood, an affordable protein source, is expected to increase significantly. To meet this rising demand, aquaculture must embrace innovative and disruptive technologies. Robotics, information technology, IoT, and digital sensors offer promising solutions for revolutionizing the industry. While aquaculture has been slower to adopt new technologies compared to other sectors, recent advancements demonstrate their potential for sustainable and profitable practices. These technologies have shown their ability to transform specific areas of aquaculture, albeit on a smaller scale.

As this study explores the potential impact of IoT in aquaculture, focusing on water quality monitoring and disease prevention to enhance sustainability of the sector, it discusses various IoT applications in aquaculture, including water quality monitoring, feed automation systems, environmental control systems, fish tracking and monitoring systems, remote monitoring and control systems, smart harvesting systems, and disease detection and prevention systems.

Despite the availability of advanced technologies, their practical implementation in aquaculture remains challenging. Integrating diverse technologies into aquaculture systems requires careful consideration of equipment types, quantities, compatibility, and communication protocols. Establishing standardized parameters for aquatic facilities is crucial for effective integration. Achieving this level of integration is complex and often beyond the capabilities of individual farmers or companies. Collaboration among fish farmers, scientists, engineers, software developers, and financial institutions is essential to successfully integrate these technologies and drive sustainability and profitability. Governments can play a role by funding multidisciplinary research and supporting startups focused on technology integration. Emerging technologies offer significant potential to enhance resource and energy efficiency, create business opportunities, and promote gender and youth inclusion. However, it's important to address potential barriers, such as the high cost of certain IoT sensors for small-scale farmers. Effective management is crucial to ensure that these technologies are utilized to improve, rather than hinder, the sustainability of aquaculture **(FAO, 2020)**.

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Appendix 1 : Survey Questions

Q1. Personal information:

1. Age
2. Years of Experience
3. Have you heard about Internet of Things technology and smart sensors before (yes or no)
4. Would you like to experience the technology of the Internet of Things and smart sensors (wants or not)

1. السن
2. عدد سنوات خبرة
3. هل سمعت عن تكنولوجيا انترنت الأشياء والمستشعرات الذكية من قبل (نعم ام لا)
4. هل ترغب في تجربة تكنولوجيا انترنت الاشياء والمستشعرات الذكية (ارغب او لا ارغب)

Q2. Performance Expectancy

1. Using Internet of Things technology and smart sensors can enhance your productivity.
2. The Internet of Things and smart sensors can contribute to improving fish health.
3. Using IoT and smart sensors will make managing your fish farm easier.
4. IoT and smart sensors can help improve the quality of your products
5. The Internet of Things and smart sensors can help reduce the time taken for routine tasks.
6. Using IoT technology and smart sensors in aquaculture will become an important part of your routine and practices.
7. Using Internet of Things technology and smart sensors in aquaculture will save costs and improve financial returns.

1. استخدام تقنيه انترنت الأشياء واجهزه الاستشعار الذكية يمكن ان يعزز انتاجيتك
2. إنترنت الأشياء والمستشعرات الذكية يمكن أن يساهم في تحسين صحة الأسماك
3. استخدام إنترنت الأشياء والمستشعرات الذكية سيؤدي إلى تسهيل إدارة مزرعتك السمكية..
4. إنترنت الأشياء والمستشعرات الذكية يمكن أن تساعد في تحسين جودة منتجاتك.
5. إنترنت الأشياء والمستشعرات الذكية يمكن أن تساعد في تقليل الوقت المستغرق للمهام الروتينية.

6. استخدام تكنولوجيا إنترنت الأشياء والمستشعرات الذكية في تربية الأحياء المائية سيصبح جزءًا مهمًا من روتينك وممارساتك.
7. استخدام تكنولوجيا إنترنت الأشياء والمستشعرات الذكية في تربية الأحياء المائية سيؤدي إلى توفير التكاليف و تحسين العوائد المالية

Q3. Effort Expectancy

1. IoT technology and smart sensors are easy to learn and use in your aquaculture operations.
2. IoT and smart sensor technology are easy to integrate into your existing aquaculture practices.
3. It's easy to make your IoT system and smart sensors do what you want it to do.
4. Data collected through IoT devices and smart sensors in aquaculture is reliable and accurate.
5. Find new and advanced IoT and smart sensor solutions to enhance your aquaculture practices.

1. من السهل تعلم واستخدام تكنولوجيا إنترنت الأشياء والمستشعرات الذكية في عمليات تربية الأحياء المائية لديك.
2. من السهل تعلم تكنولوجيا إنترنت الأشياء والمستشعرات الذكية في ممارسات تربية الأحياء المائية الحالية لديك.
3. من السهل جعل نظام إنترنت الأشياء والمستشعرات الذكية يفعل ما تريده أن يفعله.
4. البيانات التي يتم جمعها من خلال أجهزة إنترنت الأشياء والمستشعرات الذكية في تربية الأحياء المائية موثوقة ودقيقة.
5. سوف ابحث عن حلول إنترنت الأشياء والمستشعرات الذكية الجديدة والمتقدمة لتعزيز ممارسات تربية الأحياء المائية لديك.

Q4. Social Influence

1. If you decided to implement IoT and smart sensors, you have the necessary resources (such as funding, infrastructure, and a reliable internet connection) to adopt and implement IoT and smart sensor technology in aquaculture
2. You will receive adequate technical support and assistance in implementing and using IoT devices and smart sensors for aquaculture.
3. I have access to training programs or workshops to enhance your skills in using IoT technology and smart sensors in aquaculture.
4. There will be help available for me if I have difficulties using IoT and smart sensors.
5. There is sufficient infrastructure available to support the use of IoT in aquaculture.

1. إذا قررت تنفيذ إنترنت الأشياء وأجهزة الاستشعار الذكية، فلديك الموارد اللازمة (مثل التمويل والبنية التحتية والاتصال الموثوق بالإنترنت) لاعتماد وتنفيذ إنترنت الأشياء وتكنولوجيا الاستشعار الذكية في تربية الأحياء المائية

2.. ستتلقى الدعم الفني والمساعدة الكافية في تنفيذ واستخدام أجهزة إنترنت الأشياء وأجهزة الاستشعار الذكية لتربية الأحياء المائية.
3. يمكنني الوصول إلى برامج تدريبية أو ورش عمل لتعزيز مهاراتك في استخدام تكنولوجيا إنترنت الأشياء وأجهزة الاستشعار الذكية في تربية الأحياء المائية.
4. ستكون هناك مساعدة متاحة لي إذا كنت أواجه صعوبات في استخدام إنترنت الأشياء وأجهزة الاستشعار الذكية.
5. تتوفر بنية تحتية كافية لدعم استخدام إنترنت الأشياء في تربية الأحياء المائية.

Q5. Behavioral Intention

1. I intend to use or will continue to use IoT technologies (such as smart sensors) in the future.
2. I always try to use IoT technologies in my daily work.
3. I plan to use or will continue to use IoT technologies frequently in the future.
4. I will suggest IoT technologies to other farmers.

1 . أنوي استخدام تقنيات إنترنت الأشياء (مثل أجهزة الاستشعار الذكية) أو سأستمر في استخدامها في المستقبل.
2 أحاول دائمًا استخدام تقنيات إنترنت الأشياء في عملي اليومي.
3 أخطط لاستخدام تقنيات إنترنت الأشياء أو سأستمر في استخدامها بشكل متكرر في المستقبل.
4 سأقترح تقنيات إنترنت الأشياء على المزارعين الآخرين.

Q6. User Behavior

1. I use all IoT related applications.
2. I have a clear idea of how to use IoT systems.
3. I will use IoT systems again.

1 . أستخدم جميع التطبيقات المتعلقة بإنترنت الأشياء.
2 . لدي فكرة واضحة عن كيفية استخدام أنظمة إنترنت الأشياء.
3 . سأستخدم أنظمة إنترنت الأشياء مرة أخرى.